FROM PHYSICAL LAYOUT TO SPATIAL EXPERIENCE: UNDERSTANDING THE IMPACT OF VISUAL INTERFACES ON TEAMWORK IN PRIMARY CARE CLINICS

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To my families in Seoul and Atlanta for their love and prayers

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LIST OF SYMBOLS AND ABBREVIATIONS

BH	Behavioral Health
LPN	Licensed Practical Nurse
MA	Medical Assistant
PSC	Patient Service Coordinator
PR	Provider
RC	Referral Coordinator
RN	Registered Nurse
ROOM	Rooming Nurse
SW	Social Worker

SUMMARY

Teamwork among healthcare providers is critical for the safety and quality of patient care. Multiple national strategies and programs have been developed and recommended for implementation of a team-based approach to primary care, and many healthcare organizations are adopting team-based primary care clinics. However, little is known about how clinic layouts can support the teamwork of staff members in team-based primary clinics. To date, there has been little agreement on how clinic layouts should be designed to support the teamwork experiences of staff members and patients. Thus, different healthcare organizations advocate for unique and significantly different types of team-based clinic layouts.

This study looked at four team-based primary care clinics to empirically investigate the relationships between visibility metrics and both patients' and staff members' teamwork experience. The results of the study showed that the visual interfaces between staff members and patients, as well as between different groups of staff members, were found to have significant associations with awareness, communication, backstage communication, and overall perception of teamwork.

While no specific differences in awareness perceptions were reported between clinics, some negative consequences resulting from the lack of staff's ability to see the clinic area and other staff members were observed. Staff members had to spend additional time searching for each other and had their patient care process obstructed when they could not see the clinic area or other staff workstations. The visual interface between staff workstations also significantly predicted staff communication patterns. Clinics providing

more visual connections between staff workstations reported stronger perceptions of timely and frequent communication, and staff members talked frequently to other staff members whose workstations were visually and physically connected with their own workstations. Furthermore, clinics providing more visual connections between staff workstations reported higher teamwork perception. Surprisingly, more visual connections between patients and staff workstations were associated with lower teamwork perceptions from the patients' perspective. The visual connections between patients and staff workstations (visual exposure to patients) also negatively affected staff backstage communication patterns. Clinics with higher visual exposure levels reported higher levels of concern for privacy while communicating patient information, and the staff members across all four clinics preferred not to talk about patients at visually exposed areas, even if the locations were inside team areas.

The findings of the study support designing team-based primary care clinics to enhance the teamwork experience of both staff members and patients. It is worth noting that this study investigates the teamwork experience of not only staff members but also patients, who are critical entities of teamwork for patient-centered care in primary care clinics. The design implications are expected to be applicable for the teamwork of other settings, especially for strong programs where both inhabitants and visitors exist as main user groups of the spaces.

CHAPTER 1. EXECUTIVE SUMMARY

1.1 Background

Teamwork among healthcare providers is critical for safety and quality of patient care (D. Baker, Salas, Battles, & King, 2011; D. P. Baker, Day, & Salas, 2006; Joint Commission, 2008; Leonard, Graham, & Bonacum, 2004; O'Leary et al., 2012). The emphasis on teamwork is not surprising, considering the fact that 70 percent of medical errors are due to communication failures (Leonard et al., 2004; Studdert, Brennan, Thomas, Rosenthal, & Sutcliffe, 2002). Many studies have identified the failure of teamwork and communication as one of the main causes of preventable adverse events (Elder & Dovey, 2002; Joint Commission, 2008; Manser, 2009).

Benefits of team-based approach are clear. Effective teamwork and communication can reduce medical errors (Leonard et al., 2004), and improve patient outcomes (Alexander et al., 2005; Baggs et al., 1999; Gittell et al., 2000; Manser, 2009; Stephen M. Shortell et al., 1994; Wheelan, Burchill, & Tilin, 2003). Teamwork has been also found to be positively related to caregiver outcomes (Lederer, Kinzl, Trefalt, Traweger, & Benzer, 2006; Manser, 2009; Nielsen, Yarker, Randall, & Munir, 2009; O'Leary et al., 2012; Stephen M. Shortell et al., 1994; Sinsky et al., 2013; Sluiter et al., 2005). Better communication and teamwork were found to be associated with higher satisfaction (Sinsky et al., 2013), less emotional exhaustion (Sluiter et al., 2005), lower burnout level (Lederer et al., 2006), higher nurse retention (O'Leary et al., 2012; Stephen M. Shortell et al., 1994), and joy in practice (Sinsky et al., 2013). Thus, improving teamwork and communication between caregivers can enhance patient safety and caregiver outcomes.

Primary care settings have received less attention compared to dynamic settings such as surgery or emergency department (Goldberg, Beeson, Kuzel, Love, & Carver, 2013; Webster et al., 2008) despite the increasing volume of primary care visits, with 565 million projected visits by 2025 (Petterson et al., 2012). Primary care settings are different from secondary care settings (Morgan, Pullon, & McKinlay, 2015). A primary care practice is "the patient's first point of entry into the healthcare system and as the continuing focal point for all needed healthcare services (American Academy of Family Physicians, n.d.)." Primary care clinics not only provide medical care, but also "health promotion, disease prevention, health maintenance, counseling, patient education, diagnosis, and treatment of acute and chronic illnesses in a variety of healthcare settings (American Academy of Family Physicians, n.d.)." Such comprehensive care delivery requiring various professionals and skills is one of the main reasons team-based approach to primary care is emphasized (Xyrichis & Lowton, 2008).

Teamwork plays a critical role in most healthcare settings, and the importance of teamwork in primary care has been consistently advocated (Delva, Jamieson, & Lemieux, 2008; Jesmin, Thind, & Sarma, 2012; Samuelson, Tedeschi, Aarendonk, De La Cuesta, & Groenewegen, 2012; Shoemaker et al., 2016). Teamwork and communication are identified as the main causes of medical errors in primary and ambulatory care settings (Elder & Dovey, 2002; Webster et al., 2008), and improved teamwork in primary care has shown significant positive relationships with patient outcomes (Goldberg et al., 2013; Hogg et al., 2009; Jesmin et al., 2012; Kanter, Martinez, Lindsay, Andrews, & Denver, 2010; McLean, McAlister, Johnson, & et al., 2008; Pape, Hunt, Butler, & et al., 2011; Rosser, Colwill, Kasperski, & Wilson, 2011). Team-based primary care improved patients'

perception of their care process and outcomes (Jesmin et al., 2012), improved quality of care (Goldberg et al., 2013; Hogg et al., 2009; Kanter et al., 2010), and improved patient satisfaction (Goldberg et al., 2013; Rosser et al., 2011). In addition, team-based approach helped caregivers manage increasing workloads and engage in meaningful work, showing improved employee satisfaction (Goldberg et al., 2013).

Multiple national strategies and programs have been developed and recommended for implementation of team-based approach in primary care (Agency for Healthcare Research and Quality, n.d.; King et al., 2008; Mitchell et al., 2012; National Committee for Quality Assurance, n.d.; Schottenfeld et al., 2016). The core characteristics of the team-based approaches are forming coherent and identifiable care teams with a range of clinical personnel and developing continuous relationships with patients (Schottenfeld et al., 2016). Through team-based care, the patient-provider encounters are expected to be transformed from multiple disconnected episodes of seeing a single provider, to continuous and reinforced involvement with care team members (Schottenfeld et al., 2016). Team-based primary care is expected to (a) allow providers to focus on patient care with labor inputs of other health professionals, (b) be cost-effective by coordinating multiple services, (c) enable patients to receive all necessary care in a single appointment, and (d) perform better as a team with shared knowledge and skills (Jesmin et al., 2012).

Built environments play a significant role in teamwork. A considerable and growing body of literature reported the impact of built environments on team awareness, communication, and collaboration. For instance, workspace layouts that enable visual and physical integration of employees were found to support team awareness (Penn, Desyllas, & Vaughan, 1999; Peponis et al., 2007), communication and collaboration (Allen, 1970;

Kraut, Egido, & Galegher, 1988; Markhede & Koch, 2007; Penn et al., 1999; Rashid, Boyle, & Crosser, 2014; Rashid, Kampschroer, & Zimring, 2006; Sailer, Budgen, Lonsdale, Turner, & Penn, 2007; Serrato & Wîneman, 1999; Wineman & Serrato, 1997). However, little is known about how clinic layouts can support the teamwork of staff members in team-based primary clinics. Most studies have investigated teamwork in workplace settings, and only a few studies explored healthcare settings (Gharaveis, Hamilton, & Pati, 2017). Even fewer studies have looked into primary care clinics (Gunn et al., 2015; Patterson et al., 2015; Pullon, Morgan, Macdonald, McKinlay, & Gray, 2016).

The main difference between workspace and healthcare settings that this study emphasizes is the fact that in healthcare settings, "visitors"—people who do not have a permanent role in the setting—are a core group of users of the space. There are always patients in the healthcare setting, while not all workspace settings have visitors in their spaces. The presence of patients and families become more critical in team-based care since the team-approach advocate them as part of the team (Mitchell et al., 2012). Buildings regulate interfaces between inhabitants and visitors, and between different groups of inhabitants (Hillier, Hanson, & Peponis, 1984). Spatial interfaces can be defined as spatial relationships between two categories of users formed by layouts regulating opportunities and ways they meet and interact. The research to date has tended to focus on the spatial interfaces between inhabitants rather than between inhabitants and visitors, partly due to the nature of the settings of the studies. Furthermore, hospitals and clinics are a "strong program," where a relatively narrow range of activities occur in specifically designated areas (Hillier et al., 1984). For instance, patients mainly visit waiting areas, exam rooms, and other treatment rooms, and they are not allowed to access staff-only areas. In such a

programmed team-based primary care setting, specific interfaces between users (staff members and patients) of the spaces become more critical.

This research investigates team-based primary care clinics to explore how visual interfaces between different groups of users—patients and staff members—impact teamwork of staff members from the perspectives of both patients and staff members. Among various spatial interfaces between the user groups, this study focuses on visual attributes of the interfaces, which is found to be closely related to teamwork (Gharaveis, Hamilton, Pati, & Shepley, 2017; Heerwagen, Kampschroer, Powell, & Loftness, 2004). Since the main focus of the study is to investigate the relationships between built environments and user experiences, this study defines teamwork as at least two individuals—healthcare providers and other staff members in primary care clinics in this study—with different sets of skills, physically collocated in the same building, who are working collaboratively from the need to coordinate with each other to achieve shared goals. In this study, the teamwork of staff members in team-based primary care clinics refers to the provision of health services to patients through continuous coordination between at least two staff members of the clinic in the same facility to achieve high-quality care. For example, a specialist located in another clinic who receives a referral from a primary care provider or a janitor who does not participate in the patient care is not considered as a team member of the primary care clinic in this study.

There are several critical aspects of teamwork in primary care clinics. First, staff members need to be aware of the presence and/or location and/or activities of other staff members. Unlike many workspace settings where employees mostly sit and work at their workstations, in primary care clinics, staff members walk around the clinic, from waiting

areas and exam rooms to their workstations in order to take care of patients throughout the day. Second, staff members need to continuously coordinate with each other by briefing/updating/informing each other. This is partly because staff members need to continuously process new information during the patient visit on-site. As a result, brief encounters (less than five minutes) take up most interactions in healthcare settings (Crawford & Brown, 2011). Furthermore, staff members need to communicate sensitive healthcare information without concerns for privacy breach to other patients and visitors. The most important and distinct aspect of healthcare settings is that there are patients in the settings. The presence of patients and even the perspectives of patients need to be included in the picture of the staff teamwork in primary care clinics.

This study investigates team-based primary care clinics as a case study exploring the relationship between visual interfaces and teamwork. The findings of the study support designing team-based primary care clinics to enhance the teamwork experience of both staff members and patients. It is worth noting that this study investigates teamwork experience of not only staff members but also patients, who are a critical entity of teamwork for patient-centered care in primary care clinics (Schottenfeld et al., 2016). The design implications are expected to be applicable for the teamwork of other settings, especially for strong programs where both inhabitants and visitors exist as main user groups of the spaces.

1.2 Problem Statement

There has been long-standing interest in the role of visibility in generating collaborative work in workspaces (Penn et al., 1999; Rashid et al., 2006; Rashid, Wineman,

& Zimring, 2009; Sailer et al., 2007; Sailer, Budgen, Lonsdale, Turner, & Penn, 2009). However, little is known about the role of visibility as determined by clinic layout on teamwork in team-based primary care clinics. There are only a few studies exploring the impact of clinic layouts on teamwork (Gunn et al., 2015; Patterson et al., 2015; Pullon et al., 2016), with most existing studies focused on providing shared spaces for collocation of staff members as the spatial variable. There have been no studies that have looked at how quantifiable visual metrics of layout predict teamwork.

To date, there has been little agreement on how to design clinic layouts to support the teamwork experiences of staff members and patients. Highlighting a knowledge gap in the field, there are significantly different types of team-based clinic layouts advocated for by healthcare organizations. While most layouts provide shared team spaces for collocation of staff members, they vary significantly in terms of the visual interface between staff members and patients. For instance, Kaiser Permanente recently developed a new medical office module called “Next-Gen Medical Offices” through Project RAD (Reimagining Ambulatory Design) (Bluestein, 2016, March 22). This module focuses on patient experience and opens up team areas to patients. In contrast, Veterans Affairs has advocated for a totally different type of clinic module called “on- and off-stage module” in their design guidelines, which visually disconnects staff team areas and patients (U.S. Department of Veterans Affairs, 2016).

While such specific metrics regulating the interfaces between different groups of users—staff members and patients—have significant potential to impact their experiences, very few studies have investigated the impact of visual interfaces on staff and patient experience. More specifically, no single study exists which illustrates how the visual

measures of interfaces between staff members and patients in clinics predict key aspects of teamwork: awareness, communication, backstage communication, and teamwork perception. Therefore, this study seeks to provide an empirical foundation that illustrates the possible impact of visual interface metrics (between staff members and patients and between different groups of staff members) on patients' and staff members' teamwork experience in multiple team-based primary care clinics.

1.3 Scope and Objectives

As shown in Figure 1, this thesis consists of three main chapters (chapter 2, 3 and 4) along with an executive summary (chapter1) and concluding remarks (chapter 5). Chapter 1 provides background and summary findings, and chapter 5 is a reflective essay of the study. Chapter 2, 3, and 4 describe empirical investigations exploring the impact of different sets of visual interfaces on various aspects of teamwork: awareness, communication, backstage communication, and perception of teamwork. Chapter 2 and 3 focus on the perspectives of staff members, and chapter 4 looks at the perspectives of both staff members and patients. The main questions for each chapter are:

- Chapter 2: how do the visual relationships between staff members predict staff members' critical teamwork skills, awareness, and communication?
- Chapter 3: how does the presence of patients and the visual exposure of the clinic area to patients affect staff backstage communication patterns?
- Chapter 4: how does the visual access to staff members predict both staff members' and patients' overall perception of teamwork?

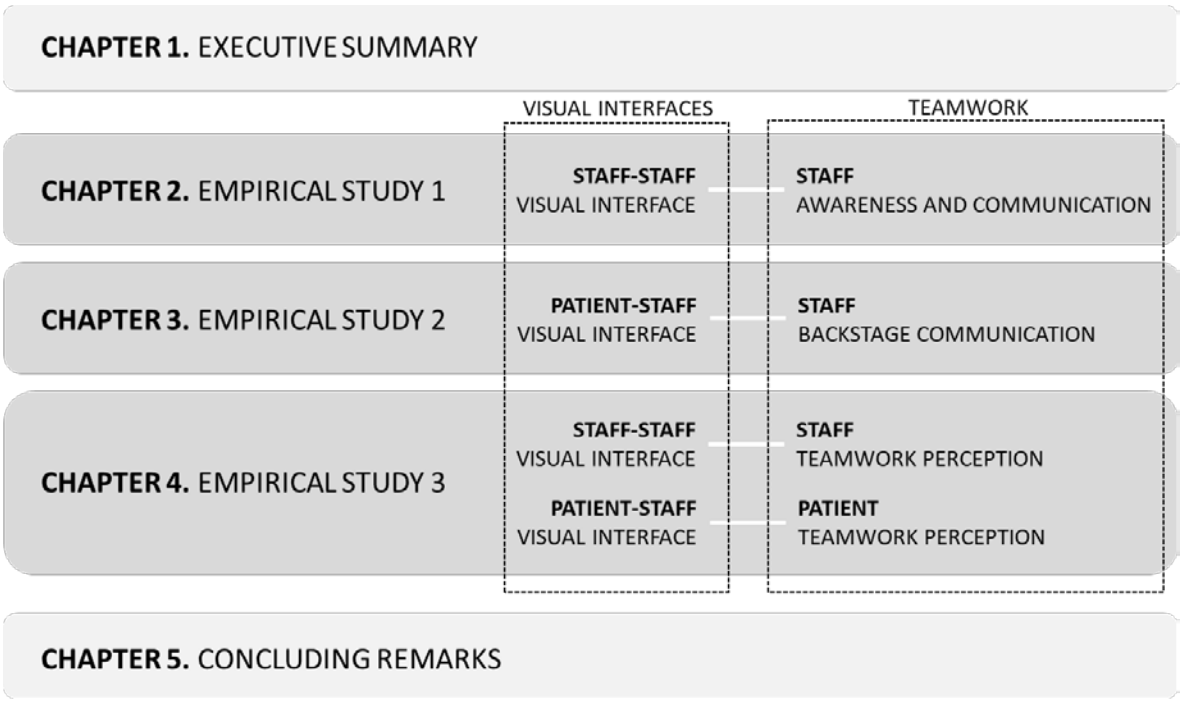


Figure 1 – Structure of the thesis.

In chapters 2, 3, and 4, this study empirically investigates a total of four team-based primary care clinics. The four clinics were chosen since they a) are associated with healthcare organizations advocating for team-based approach, b) show a range of team-layout modules reflecting the current debate in the field, and c) provided access to their floorplans and clinics to the author. While there are many clinics adopting various team-layout modules in their clinic design, not all clinic design modules are investigated in this study due to limited access, availability, and time. This thesis investigates the four clinics, which show a range of clinic design modules, focusing on the relationships between the visual interfaces and teamwork experiences of staff members and patients.

These four clinics are team-based primary care clinics and have shared team spaces in the clinics. However, there are inevitable differences beyond the clinic layouts that this study did not control, including healthcare organizations, clinic sizes, technology, and

culture. This thesis was an opportunity to study the four clinics, acknowledging the differences between them beyond the built environments, for finding preliminary design implications for teamwork.

1.4 Empirical Findings

Visual interfaces between staff members and patients, and between different groups of staff members were found to have significant associations with awareness, communication, backstage communication, and overall perception of teamwork.

While no specific differences in awareness perceptions were reported between clinics, some negative consequences of the lack of staff's ability to see clinic area and other staff members were observed. Instances that staff members had to spend more time finding each other and had their patient care process obstructed were observed when they could not see the clinic area or other staff workstations.

The visual interface between staff workstations also significantly influenced staff communication patterns. Clinics providing more visual connections between staff workstations reported stronger perceptions of timely and frequent communication, but they were not associated with observed communication frequency. While it was hypothesized that staff members would communicate more frequently in clinic areas where they could see more staff workstations, staff members talked to each other mostly around their workstations rather than visually accessible clinic areas. They talked frequently to other staff members whose workstations were visually and physically connected with their workstations.

Furthermore, clinics providing more visual connections between staff workstations reported higher teamwork perception. Surprisingly, however, more visual connections between patients and staff workstations were associated with lower teamwork perceptions from patients' perspective.

The visual connections between patients and staff workstations (visual exposure to patients) also negatively affected staff backstage communication patterns. Clinics with higher visual exposure levels reported higher levels of concern for privacy while communicating patient information, and the staff members across all four clinics preferred not to talk about patients at visually exposed areas, even if the locations were inside team areas.

1.5 Significance and Implications

The research has significant implications from the empirical findings for study settings, methodological approach, and practice/design. The significance and expected implications of this thesis are as follows.

Study settings:

- Illustrates detailed pictures of how teamwork occurs at four different primary care clinics with diverse teamwork measurement results
- Examines perspectives of both staff members and patients for patient-centered teamwork in primary care clinics
- Provides opportunity to apply visual metrics in other settings beyond team-based primary care clinics to assess layout for the teamwork of inhabitants and visitors

Tools and metrics:

- Emphasizes the importance of adopting an agent perspective in the assessment of visibility
- Validates the usefulness of recently developed analysis tool for agent-based visibility analysis, VisualPower
- Identifies specific visual interface metrics as descriptors of the clinical layout for teamwork, which can be used to provide quantifiable metrics for assessment of clinic layouts
- Provides diverse measurements for assessing teamwork, including the newly written survey items and location preference survey
- Provides spatial metrics that are strongly associated with teamwork by testing the relationships between visual metrics and teamwork outcomes

Practical and design implications:

- Provides preliminary findings of how the openness of team room to patients is associated with patients' perspective of teams
- Illustrates possible impacts of various clinic layouts on teamwork in relation to the levels of visibility interface metrics
- Describes design implications for enhancing teamwork of staff members in team-based primary clinics
- Supports architects and stakeholders during the early design stage for understanding the possible impact of clinic layout on teamwork experiences of both staff and patient

CHAPTER 2. THE EFFECT OF VISUAL CONNECTIONS BETWEEN STAFF MEMBERS ON THEIR AWARENESS AND COMMUNICATION

This chapter examines how visual relationships between staff members, and even different groups of staff members, predict their critical teamwork skills, awareness, and communication.

2.1 Introduction

In 1999, the Institute of Medicine (IOM) reported frightening findings about patient safety in the United States (Kohn, Corrigan, & Donaldson, 1999). The report concluded that between 44,000 and 98,000 Americans die annually due to medical errors, resulting in approximately $17 to $29 billion indirect costs (Kohn et al., 1999). In order to reduce medical errors and improve patient safety, the IOM pointed out the need for enhanced teamwork in a set of recommendations (Kohn et al., 1999). Recognizing the importance of teamwork, many primary clinics and healthcare organizations are moving toward team-based care (Kennedy & Nordrum, 2015; National Committee for Quality Assurance, n.d.; Schottenfeld et al., 2016; U.S. Department of Veterans Affairs, n.d.). However, little is known about how clinic layouts should be designed to support the teamwork of staff members.

Awareness and communication are two key aspects of teamwork in work settings (Alonso et al., 2006; Barach & Weinger, 2007; Flin & Maran, 2004; Leonard et al., 2004; Manser, 2009; Salas, Sims, & Burke, 2005; Wauben et al., 2011). Built environments play

a significant role in supporting or hindering awareness (being aware of the presence and/or location and/or activities of other staff members) and communication (exchanging information via face-to-face interactions) between team members. A significant and growing body of literature explored the effect of built environments on team awareness (Bolstad, Cuevas, Gonzalez, & Schneider, 2005; Cai & Zimring, 2012; Gunn et al., 2015; Lu & Zimring, 2012; Penn et al., 1999; Peponis et al., 2007) and communication (Allen, 1970; Bolstad et al., 2005; Cai & Zimring, 2012; Gunn et al., 2015; Kraut et al., 1988; Markhede & Koch, 2007; Penn et al., 1999; Rashid et al., 2014; Rashid et al., 2006; Sailer et al., 2007; Serrato & Wîneman, 1999; Wineman & Serrato, 1997). However, most studies were conducted in non-medical workspace settings (Gharaveis, Hamilton, & Pati, 2017); only a few studies have explored the impact of clinical layouts on teamwork in primary clinics (Gunn et al., 2015; Patterson et al., 2015; Pullon et al., 2016).

Several of these studies have quantified spatial properties of the built environments. To date, there is lack of quantified spatial properties on staff awareness and communication. Many studies focus on overall layout properties (Cai & Zimring, 2012; Lu & Seo, 2012; Penn et al., 1999; Penn & Hillier, 1992; Peponis et al., 2007; Sailer et al., 2007, 2009; Serrato & Wîneman, 1999; Wineman & Serrato, 1997), or existence of certain spaces such as shared team rooms (Bolstad et al., 2005; Boutellier, Ullman, Schreiber, & Naef, 2008; Gunn et al., 2015; Ying Hua, Becker, Wurmser, Bliss-Holtz, & Hedges, 2012; Pullon et al., 2016; Rashid et al., 2014), rather than interpersonal relationships determined by the space. While overall layout properties provide meaningful insights into design strategies, healthcare setting is a strong program where a limited range of activities occur in specified locations (Hillier et al., 1984). In such a programmed setting, the importance

and meaning of spaces become different to individuals depending on their roles and goals. For instance, patient rooms become more of importance (than overall layout) for nurses in intensive care units (Lu & Zimring, 2012). The differential weights of spaces make spatial properties of the specific spaces critical in strong program settings. Focusing on the agents of the visibility—staff members, this study quantifies specific visual metrics between staff members determined by clinic layout and team room design. The agent-based visibility analysis is enabled by a recently developed visibility analysis tool, VisualPower (Lim, Kim, & Zimring, 2018).

While many healthcare organizations are advocating for team-based clinic layouts, there has been little agreement on how to design clinics to support the teamwork of staff members. More specifically, there are various ways that clinic layouts and team room designs determine visual interfaces—visual relationships between two categories of users (staff-staff or patient-staff) formed by clinic layouts regulating opportunities and ways they meet and interact—between staff members. Among many clinics who adopt a team-based approach in their clinic design, this study empirically investigates four team-based primary care clinics with a range of visual interfaces between staff members, made possible by access to the clinics and users given to the author.

The purpose of this study is to see whether specific metrics of the visual interfaces predict staff awareness and communication. The findings and insights of this study are expected to inform designers, researchers, healthcare leadership, and facility managers concerned with improving teamwork by increasing awareness and communication among staff members through the design of the team-based primary care clinics.

2.2 Theoretical Foundation and Literature Review

2.2.1 Critical Teamwork Skills: Awareness and Communication

Teamwork has been continuously studied in various fields such as aviation, the military, and healthcare (O'Leary et al., 2012). Many studies document the impact of different aspects of team member cognition, affect, and behavior that support or hinder teamwork (Alonso et al., 2006; King et al., 2008; Salas et al., 2005). For instance, Salas et al. (2005) identified eight core factors of teamwork in their extensive literature review, which was followed by Alonso et al. (2006)'s four core teamwork competencies: leadership, situation monitoring (mutual performance monitoring), mutual support (backup behavior), and communication. They argued that the four skills are trainable and critical to all teams (Alonso et al., 2006), and the model was empirically tested to have a good fit (D. Baker et al., 2011; Keebler et al., 2014).

In addition, among various teamwork skills, there are core skills that are found to be the most important for patient safety. Wauben et al. (2011) identified communication, situation awareness, and teamwork as the most critical non-technical skills in a surgical environment. The importance of communication for patient safety cannot be overstated since effective communication is critical for the success of teamwork resulting in the patient safety and quality of care (Barach & Weinger, 2007; Leonard et al., 2004; Manser, 2009). Situation awareness has been identified as one of the most important competencies (Leonard et al., 2004), especially in trauma care (Barach & Weinger, 2007) and acute care (Flin & Maran, 2004). While the nature of dynamic settings such as trauma or surgical settings differs from that of the primary care setting, Alonso et al. (2006) identified

communication and situation awareness/monitoring as critical teamwork skills that all teams require regardless of the team tasks.

The purpose of this study is understanding the role of built environment on two key teamwork skills: namely, awareness and communication. This study does not attempt to define the framework of the teamwork, but instead, focuses on critical teamwork skills of team members and their association with built environments. Among the teamwork skills that were identified as the most important (Wauben et al., 2011) and trainable (Alonso et al., 2006), this study focuses on teamwork skills that built environments may plausibly impact. For instance, while leadership is an important skill, as part of the "Big Five (Salas et al., 2005)," it may be less impacted by built environments because it is more of an intrinsic factor of leaders. This study primarily examined the impact of built environments on the two teamwork skills, situation monitoring/awareness, and communication.

2.2.2 Awareness and Built Environments

Situation awareness is defined as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future (Endsley, 1995, p. 36)," and it has three levels: perceiving critical factors (level 1), understanding the meanings (level 2), and projecting the future (level 3) (Endsley, 1996, 2000). Built environments may support or hinder situation awareness of team members by controlling the accessibility of critical information as a layer of the system. Degrees of accessing and perceiving critical factors may vary depending on the location of individuals and the spatial attributes of each location as determined by the built environments. For instance, a staff member may be able to see

all other staff members at a specific location, but not at all at another location, impacting the individual's level of awareness of other staff members.

Not many studies have focused on situation awareness as an outcome of their study in relation to the spatial properties of the built environment. These limited number of studies confirmed or asserted that situation awareness is highly associated with visibility (or visual exposure), determined by various levels of spatial attributes: overall layout (Cai & Zimring, 2012; Lu & Zimring, 2012; Peponis et al., 2007), location of specific programs in relation to the overall layout (Cai & Zimring, 2012; Lu & Zimring, 2012; Penn et al., 1999; Peponis et al., 2007), and physical distance between employees (Bolstad et al., 2005; Cai & Zimring, 2012; Gunn et al., 2015).

Integrated overall layout has been shown to generate movements and exposure to activities or displays in workspace that support co-awareness of the environment (Peponis et al., 2007). Lu and Zimring (2012) found that physicians locate themselves in areas with high generic visual connectivity (where they can see a larger area), which Lu and Zimring speculated to be related to better situation awareness. Being near or at highly integrated area providing more visual access also supported awareness (Cai & Zimring, 2012; Penn et al., 1999). Nurses at higher global integration values were aware of more patient rooms (Cai & Zimring, 2012), and employees at workstations near high integration areas (i.e., circulation core) were aware of more people (Penn et al., 1999).

Being able to see specific programs or targets were found to support awareness. Exposure to activities in the central hub supported awareness of what is going on in the workspace (Peponis et al., 2007), and closer visual and metric distance between nurse

alcoves allowed nurses to be aware of their peers and patient rooms (Cai & Zimring, 2012). Lu and Zimring (2012) found that nurses talk to each other in locations where they can see more patient beds, which they assumed is related to the awareness of patients. Collocated members in shared spaces were found to have better situation awareness as well (Bolstad et al., 2005; Gunn et al., 2015).

Among these previous studies, only a couple of studies subjectively measured the awareness of participants (Bolstad et al., 2005; Cai & Zimring, 2012). Other studies speculated awareness as a possible reason for observed behavioral patterns (Lu & Zimring, 2012; Penn et al., 1999), or as a possible outcome of spaces (Gunn et al., 2015; Peponis et al., 2007).

2.2.3 Communication and Built Environments

Communication between healthcare providers is critical (Alonso et al., 2006; Barach & Weinger, 2007; Ellingson, 2002; Leonard et al., 2004). While much attention has been given to electronic clinical communication, face-to-face interaction continues to play significant roles in healthcare settings (Brown et al., 2009; Coiera, 2000; Coiera & Tombs, 1998; Gharaveis, Hamilton, Pati, et al., 2017; Kilner & Sheppard, 2010; Reddy & Spence, 2008). Researchers have speculated that clinical staff members talk to each other when they see the opportunities in busy environments in order to reduce their cognitive load (Coiera, 2000; Coiera & Tombs, 1998). Face-to-face communications support rapid information exchange and coordination, especially in healthcare settings where brief encounters (less than five minutes) take up most interactions (Crawford & Brown, 2011).

While a significant body of research has been carried out on the relationships between built environments and face-to-face communications, only a limited number of studies have examined clinical communications in healthcare settings (Gharaveis, Hamilton, & Pati, 2017). Most studies were conducted in workspace settings, exploring the impact of open-plan workspaces (with better visual contacts and distance) on communication and collaboration (Allen, 2007; Heerwagen et al., 2004; Rashid et al., 2009). The empirical studies found the impact of spatial properties on communication in various spatial scales, from overall layout to distance between work areas.

Overall layout with higher integration, better visibility, and improved accessibility supported higher mean useful contact rate (Penn & Hillier, 1992), usefulness of each other (Sailer et al., 2007), and more frequent face-to-face interactions (Rashid et al., 2009; Sailer et al., 2007, 2009; Wineman & Serrato, 1997). Higher levels of communication were associated with layouts with a stronger local to global interface (Serrato & Wîneman, 1999), or radial-like units with better visibility (Lu & Seo, 2012).

The presence or properties of specific areas such as nurse stations or shared staff spaces have also been found to impact communication patterns (Boutellier et al., 2008; Gum, Prideaux, Sweet, & Greenhill, 2012; Ying Hua et al., 2012; Penn et al., 1999; Pullon et al., 2016; Rashid et al., 2014). Workspaces that have accessible shared team spaces or meeting rooms show more frequent brief interactions (Boutellier et al., 2008; Pullon et al., 2016). In healthcare settings, multi-hub designs in medical/surgical floors were found to be positively associated with more frequent, brief nurse-doctor communication (Ying Hua et al., 2012), and spaces with an adequate level of privacy from patients facilitated spontaneous conversations of staff members (Gum et al., 2012). Furthermore, spatial

properties of specific locations have been explored, providing design implications. Wineman and Adhya (2007) found that locations with higher connectivity to other corridors supported higher perception of interaction support. Locations with higher axial integration values were found to be associated with higher number of people talking with each other, providing higher possibility of contact with others (Penn et al., 1999), and frequent communications between nurses and physicians at their seats (Rashid et al., 2014).

The physical and visual relationships between individuals were also found to impact communication patterns. Individuals in close physical distance, such as those assigned to the same corridor or floor, showed higher probabilities of communication (Allen, 1970), and more frequent communication and collaboration (Kraut et al., 1988). Individuals collocated in same space showed higher "bumpability" with more face to face interaction (Gunn et al., 2015), and more communication and collaboration (Bolstad et al., 2005). Furthermore, more frequent face-to-face communications were reported at workstations with higher "intervisibility" between workstations (Markhede & Koch, 2007), and at workstations requiring lower average number of steps to other workstation alcoves (Cai & Zimring, 2012). A recent qualitative study identified visibility between staff members as a critical factor supporting staff collaborative communications (Gharaveis, Hamilton, Pati, et al., 2017). In terms of the relationship between workstations and overall space, it was found that higher visible co-presence (the number of people visible from a path of observation within the visual field from an axial line) was associated with more frequent face-to-face interactions (Rashid et al., 2006).

2.2.4 Research Questions: Visual Connections between Staff Members and its Impact on Awareness and Communication

While previous studies provide useful design implications for the overall layout from their findings, there is lack of quantified spatial properties for fine-tuned interfaces between users of the spaces. Many studies compared categorical design strategies (e.g., have shared team room or not, and nursing unit types) rather than using quantifiable spatial metrics. Most studies that used quantifiable spatial metrics explored overall layout properties such as integration values (Penn & Hillier, 1992; Sailer et al., 2009) or connectivity values (Wineman & Adhya, 2007).

A recent qualitative study highlighted the impact of visibility on staff teamwork in the emergency department and identified different types of visibility in their framework: general visibility, staff-staff visibility, and staff-patient visibility (Gharaveis, Hamilton, Pati, et al., 2017). While this study describes the fine-tuned visual relationships between different users, only general visibility was analyzed using Depthmap software (Turner, 2007). Staff-to-staff or patient-staff visual relationships were not quantified in the study perhaps due to incontrollable and unpredictable actual locations of staff members and patients, or due to lack of analysis tools.

This study quantifies staff-staff visual relationships determined by clinic layout and team area design. Rather than analyzing the spatiotemporal visual attributes of staff members, this study analyzes visual relationships between physical properties where staff members are expected to dwell, considering workstations as origins of staff visibility and clinic areas as their possible locations in the clinic. Furthermore, this study uses a newly

developed analysis tool, VisualPower, that enables agent-based visibility relationships (Lim et al., 2018). In summary, this study presents how two quantifiable visual interfaces of staff members, staff seeing clinic area or staff seeing other staff workstations, impact staff awareness and communication in team-based primary clinics.

2.3 Methods

2.3.1 Settings

This study empirically studied four primary clinics: two clinics in the Mayo Clinic system, and two clinics associated with the Emory Clinic system. Both organizations advocate team-based primary care and have expressed interest in developing clinic layouts that support and promote teamwork. The two clinics within each system were chosen since they all have physical team spaces shared by staff members including providers, and they cover a range of various team-layout modules. Beyond the team-oriented approach and layouts, there are multiple differences across the four clinics, including sizes, organizations, culture, or technology. This study acknowledges the differences between the clinics since the study design does not allow to control these differences. This study is not a controlled experiment where all potentially influential factors were kept constant, but an opportunity to investigate four different clinics where team-based care is valued and embedded in the physical spaces. Summary descriptions and floorplans of the four clinics are illustrated in Table 1 and Figure 2.

Emory Clinic A has three main team spaces shared by staff members with the same role (e.g., provider office, rooming nurse station). While these team areas are physically separated, they are visually connected to each other. Emory Clinic B also separates team

areas for specific roles of staff members: rooming nurse stations, provider stations, and an RN office. These team areas are both physically and visually separated.

Table 1 – Summary descriptions of the four team-based primary care clinics.

	Clinic A	Clinic B	Clinic C	Clinic D
Overall description				
Organization	Emory Clinic	Emory Clinic	Mayo Clinic	Mayo Clinic
Service line	Primary Care	Primary Care	Primary Care	Primary Care
Geographic location	Atlanta, GA	Atlanta, GA	Arcadia, WI	Rochester, MN
Architectural description				
Designed by	A local design firm in Atlanta, GA	A local design firm in Atlanta, GA	A national design firm with local offices	A national design firm with local offices
Year built/renovated	2011	2012	2016	2016
Layout type (Team room)	Open + Closed	Open + Closed	Open + Closed	Closed
Clinic area (centerline, sqft)	2,859	12,179	12,251	21,684
Number of exam rooms	6	28 (14+14)	13	30 (15 + 15)
Operational description				
ERM adopted before the construction	Yes	Yes	Yes	Yes
Size of enrolled patient population	11,400	4,000	4,000	15,000
Number of staff members (Admin not included)	15 totals (4 Providers; 2 RNs; 2 LPNs; 3 MAs; 1 Psychologist; 1 PSC; 1 Nutritionist)	34 totals: 9 Providers, 2 RNs, 7 LPNs; 8 MAs; 1 SW; 6 PSCs; 1 RC)	27 totals (6 Providers; 6 RNs; 5 LPNs; 2 BH; 2 Interpreters; 6 Receptionists)	60 totals (19 Providers; 10 RNs; 13 LPNs; 3 Care Coordinators; 1 SW; 1 Pharm; 1 BH; 3 Patient Appt Coordinators; 9 Clinical Assistants)
Number of teams	1 Team	2 Teams	1 Team	2 Teams
Exam room assignment	Shared by providers	Assigned per provider daily	Per provider	Shared by providers

Figure 2 – The layout of the four clinics. Grey areas represent team spaces, and blue areas indicate exam rooms.

Mayo Clinic C has one team area shared by all staff members. This clinic locates staff members with different roles together in "pods." While the clinic has one team area, the team area has five clusters of workspaces, with each cluster shared by a pod. The huddle room in the middle visually separates workstation clusters. Lastly, Mayo Clinic D has a large team area locating most staff members together. The team area is shared by two teams, and for each team, staff members with the same role are clustered together.

2.3.2 Spatial Variables: Staff Clinic Visibility and Staff Workstation Visibility

This study focused on visual relationships between staff members with two variables: how much staff members at workstations can see (1) overall clinic area (Staff Clinic Visibility) and (2) other staff workstations (Staff Workstation Visibility). While staff members may move around the clinic throughout the day, this study set staff workstations as origins of agents' visibility. Both clinic area and staff workstations are represented by points. Clinic spaces are translated into a grid of points with 1 ft. interval in clinic areas excluding waiting area. Each workstation is represented as a point in the middle of the workstation. The first variable, Staff Clinic Visibility, provides a score based on the sum of visible space-points at each workstation. The second variable, Staff Workstation Visibility, provides a score based on the sum of visible other workstation-points from each workstation. The two variables were calculated using VisualPower tool (Lim et al., 2018).

2.3.3 Awareness and Communication Measurements

Staff awareness and communication patterns were assessed using multiple methods. Both quantitative and qualitative methods were used, which included: on-site qualitative observations, phone and on-site interviews, staff surveys, and behavior mapping

observations. Two visits to four clinics were conducted between June and November 2017. A preliminary visit was performed to update floorplans and interview leaderships/administrators, which was followed by a second visit conducting staff interviews and surveys, and behavior mapping observations.

2.3.3.1 Interviews and Qualitative Observations

Clinic managers, leadership, administrators as well as staff members were interviewed during the two visits using semi-structured interviews. Qualitative field observations were conducted during the second visit, focusing on spatial behaviors of staff members. The clinics were observed for two to three weekdays. More specifically, staff awareness and communications in relation to space were mainly observed by recording locations and encounters of the staff members in the clinics.

2.3.3.2 Staff Survey

Staff members' perceptions regarding their awareness and communication were collected using a self-report measure developed for the study. The survey included a total of 17 items designed to assess multiple constructs. The survey included 4-items to assess perceptions of teamwork (Agency for Healthcare Research and Quality, 2017) and 4-items from S. M. Shortell, Rousseau, Gillies, Devers, and Simons (1991) designed to assess communication timeliness. The survey also included 9 locally-developed items: 1-item asking about communication frequency, 4-items to assess awareness, and 4-items designed to assess communication concerns about patient privacy. Among the multiple constructs, this chapter focuses on awareness and communication. Participants were asked to indicate their degree of agreement-disagreement for each item, using a 5-point Likert scale.

All possible care team staff members were asked to participate in the survey. A total of 88 staff members from the four clinics answered the survey. Unreliable responses were excluded, and a total of 83 valid responses were further analyzed (response rate = 64.3%). A factor analysis was conducted to examine the construct validity of Awareness and Communication constructs. While most items loaded on corresponding constructs, one item under the awareness construct loaded on another construct, so it was deleted from the awareness construct for further analyses. Based on the Cronbach's alpha test, the awareness items (3 items; $\alpha = .797$) and timely communication items (4 items; $\alpha = .641$) were found to be reliable.

2.3.3.3 Behavior Mapping Observations

The behavior mapping observations were conducted to record the location and the frequency of communications, using a proprietary tablet application (DuBose, Lim, & Savitsky., 2016, November). The public space and workspaces of four clinics were observed following a predetermined route for each clinic. Each observation period followed the route recording where individuals are, what their role is, what their posture is, whether they are talking, and what devices they are using. An observation period was conducted every 10, 15 or 30 minutes, depending on the size of the clinic. No identifying personal information was collected, and exam rooms were not observed.

2.3.4 Statistical analysis

In order to explore the relationships between visibility levels and measures of teamwork, multiple analyses were conducted. Staff perceptions were compared between clinics, and observed communication frequency was compared between role-specific team

areas across clinics. Spatial and outcome data were managed in multiple programs, Microsoft Excel, GIS and SPSS 22. Statistical analysis including descriptive statistics, Cronbach's alpha test, factor analysis, Kruskal-Wallis test, and correlation analyses were performed using SPSS 22 (IBM, n.d.).

2.4 Results

2.4.1 Summary Results of Independent and Dependent Variables

2.4.1.1 Staff Visibility Variables

This study explored the two staff visibility variables across clinics: staff seeing the overall clinic from their workstations, and staff seeing other staff workstations from their workstations. The first visibility variable, the number of visible other staff workstations at each workstation, is illustrated in Figure 3. Figure 4 illustrates how many other workstations each staff member can see from their workstations. The figures illustrate the number of visible points (clinic area points or other staff workstation points) from each workstation in grey color scheme, with darker color points indicating higher visibility levels of their targets. When the overall levels of the two variables are compared between clinics, Clinic A has relatively higher average values for both staff seeing clinic area (30.4%) and other staff workstations (34.1%), and Clinic B has lower average values for both variables (8.3% and 22.0%, respectively). The visibility values are aggregated in clinic levels, or in team area levels in a categorical variable for further analyses.

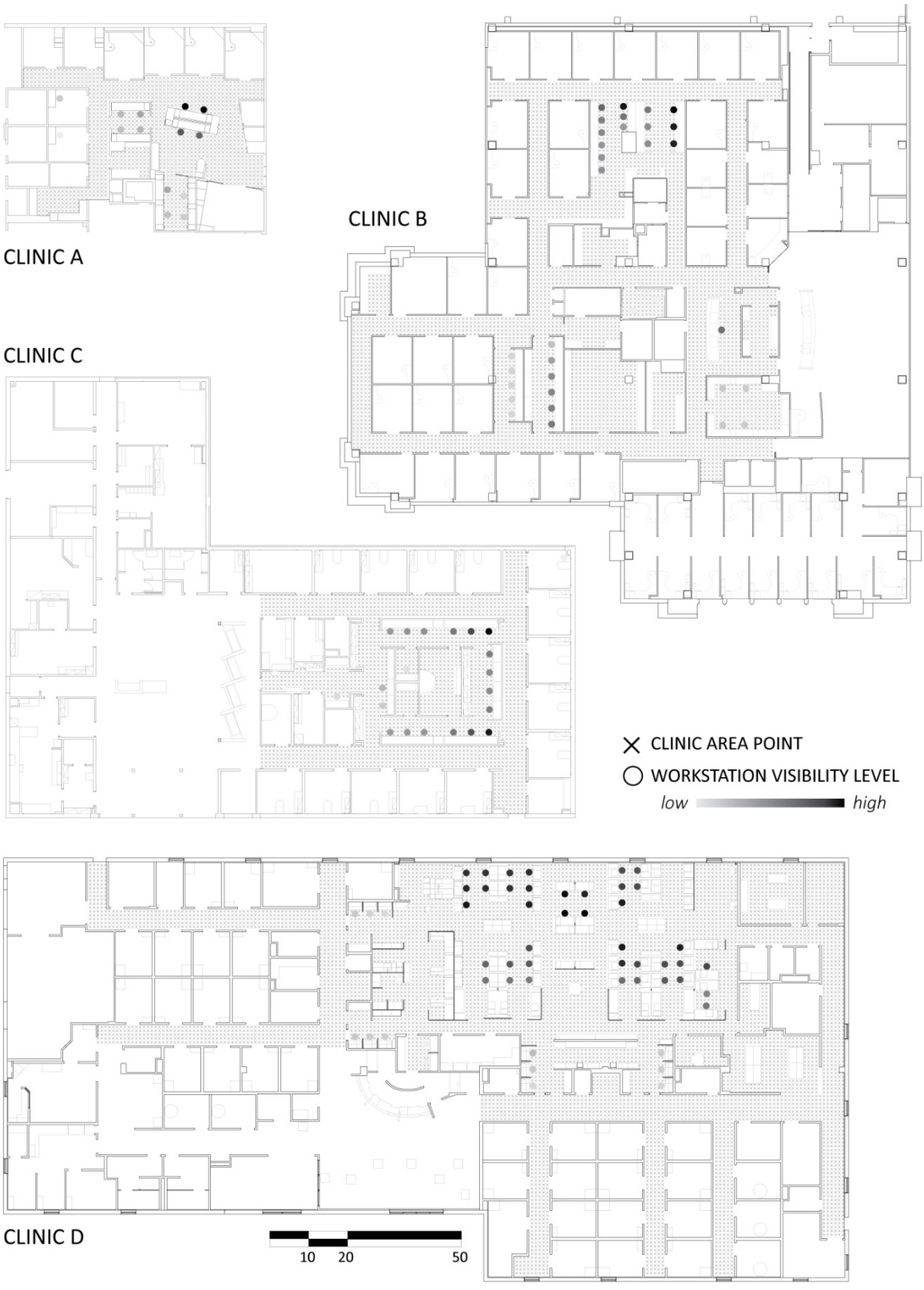


Figure 3 – Staff members seeing overall clinic space at workstations.

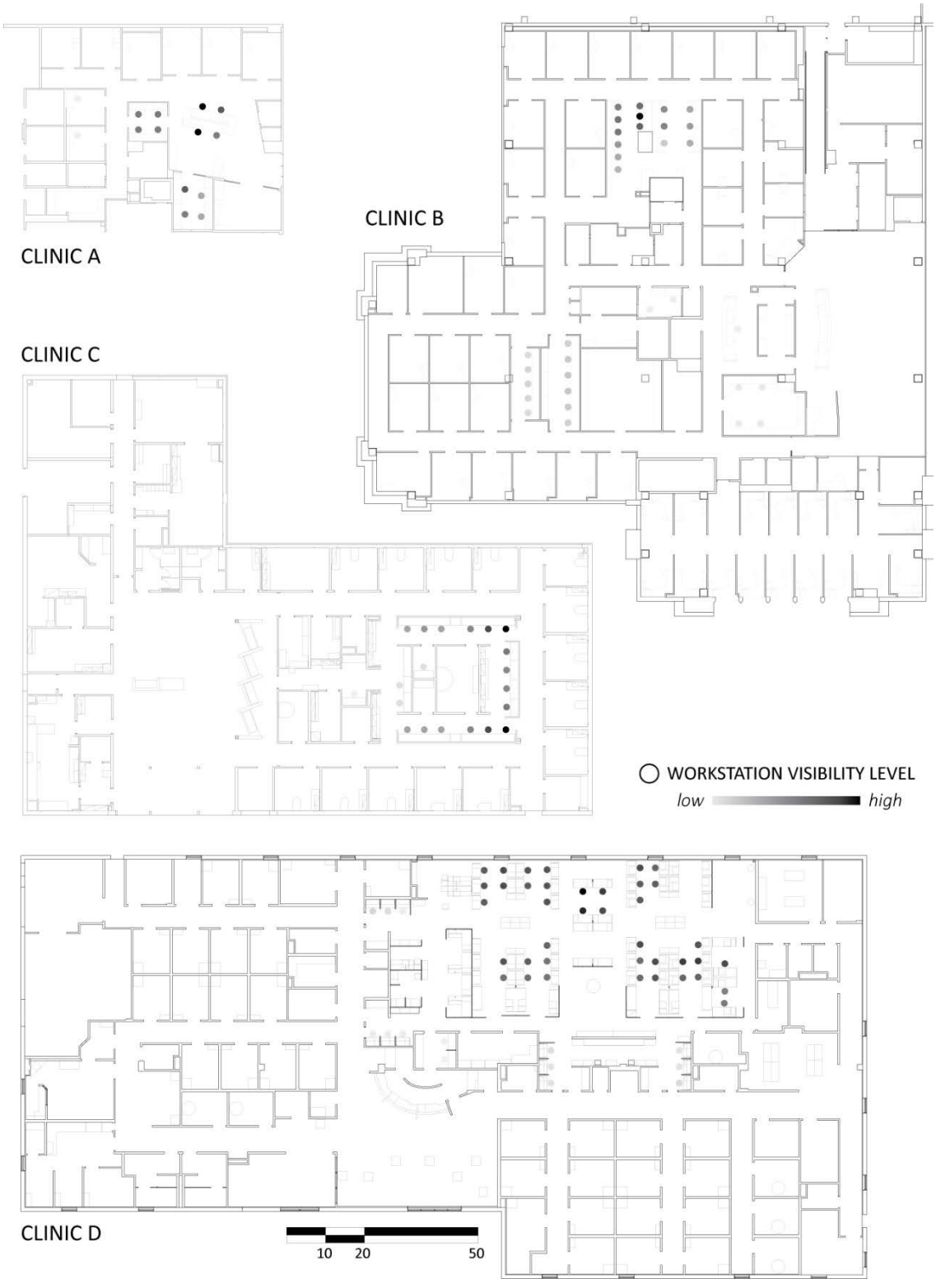


Figure 4 – Staff members seeing and being seen by each other's workstations.

2.4.1.2 Teamwork Outcome Measurements

The summary results of outcome measurements are described in Table 2. A total of 46 staff members were interviewed, 83 staff survey responses were analyzed, and 193 observation periods were collected from the four clinics. Descriptive statistics and more detailed results of the teamwork outcome measurements are described in the subsequent sections.

Table 2 – Demographic and summary results of teamwork outcome measurements.

	Clinic A	**Clinic B**	**Clinic C**	**Clinic D**	**Total**
Interviews					
Interviewees	7	8	11	20	46
Staff Survey					
All possible staff members during the visits	16	26	24	63	129
Total	14	15	19	35	83
Response rate	87.5%	57.7%	79.2%	55.6%	64.3%
Primary care provider	4	5	2	8	19
Rooming nurses (MA, LPN, etc.)	3	7	5	9	24
RNs	1	0	3	8	12
Call nurses other than RNs (LPN, appt coordinator, etc.)	2	0	0	3	5
Extended care members (specialists, care coordinators, etc.)	2	0	4	1	7
Front desk	1	3	4	3	11
Administrative personnel	1	0	1	3	5
Behavior Mapping Observations					
Observation periods	78	54	37	24	193
Intervals between periods (min)	10	15	15	30	NA
Total recorded individuals	850	661	667	1346	3524
Total recorded interacting individuals	341	236	323	436	1336
Average number of recorded individuals per period	10.9	12.2	18.0	56.1	NA
Average number of recorded interacting individuals per period	4.4	4.4	8.7	18.2	NA

2.4.2 Clinic/Workstation Visibility and Awareness

2.4.2.1 Staff seeing clinic areas and other staff workstations is necessary but not sufficient for staff awareness

The association between staff awareness perception and the two visibility variables were analyzed. The assumption of the relationships was that in clinics where staff members could see and find other staff members and workstations, they will have better situational awareness.

However, all four clinics reported similar scores of awareness perceptions as shown in Table 3. Clinics showed relatively small differences (the difference between the highest and the lowest scores are 0.29) in staff awareness scores, resulting in no statistically significant differences according to the Kruskal-Wallis H test. As shown in Figure 5, no specific tendency was found in the relationship between awareness and staff seeing clinic space. The staff visibility level of seeing other staff members seemed to have a linear tendency with staff awareness perception (Figure 6). However, the correlation analysis result was not significant ($r=.828$, $p=.086$, 1-tailed). The lack of a relationship between visibility variables and awareness scores may be due to the lack of variability in awareness scores, which might be due to a ceiling effect.

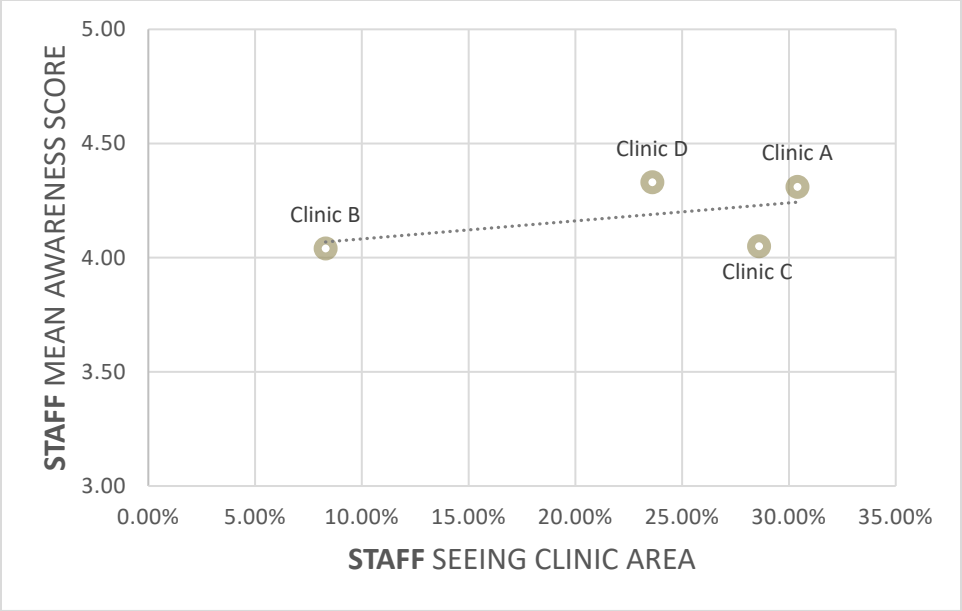


Figure 5 – Staff seeing clinic area and staff awareness perception. The four clinics have relatively high awareness perception levels regardless of the visibility of clinic area at staff workstations.

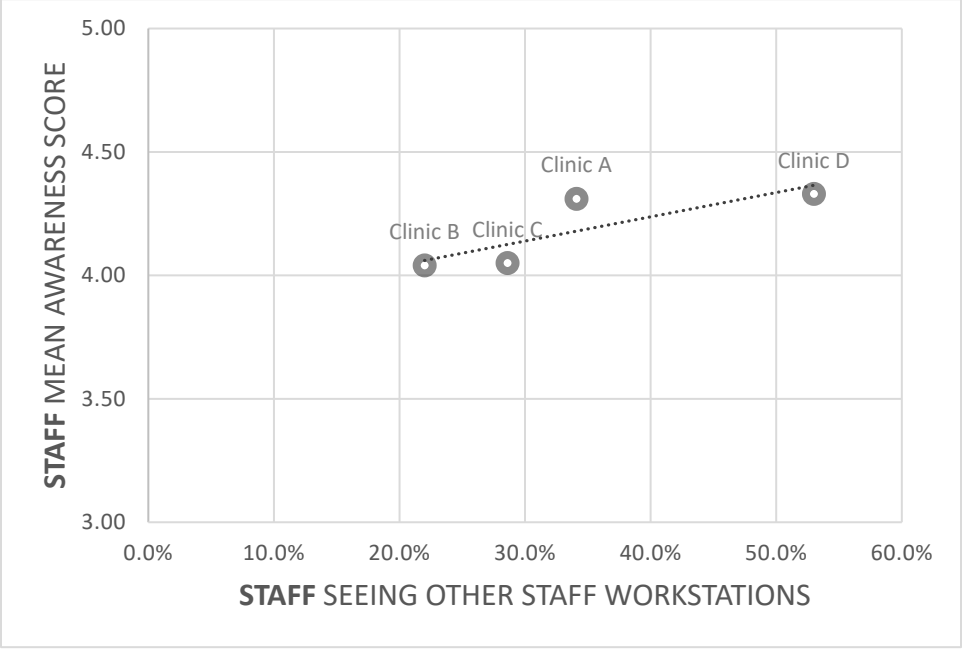


Figure 6 – Staff seeing other staff workstations and staff awareness perception. The four clinics show the slightly higher level of awareness perception when staff members can see more of other staff workstations at their workstations, but the differences between the clinics are small showing no statistical significance.

Table 3 – Results of the staff visibility variables and awareness perception per clinic.

Staff Visibility and Teamwork Variables	Clinic A	Clinic B	Clinic C	Clinic D
Staff Visibility Variables				
1. Staff members seeing overall clinic space at workstations				
Number of workstations	14	33	21	53
Average number of visible space points	363.9	382.2	625.6	1722.8
Total number of space points	1197	4591	2186	7305
Ratio (average visible points/total points)	30.4%	8.3%	28.6%	23.6%
2. Staff members seeing each other's workstations				
Number of workstations	14	33	21	53
Average number of visible other workstations	4.4	7.0	5.7	27.5
Total number of other workstations	13	32	20	52
Ratio (average visible points/total points)	34.1%	22.0%	28.6%	53.0%
Staff Teamwork Variable: awareness perception (3 items)				
Staff responses (N)	14	15	19	35
Awareness (3-item) Mean	4.31	4.04	4.05	4.33
Awareness (3-item) SD	0.58	0.53	0.74	0.72

There were some qualitative findings highlighting the negative impacts of the lack of staff visibility on staff awareness, while staff awareness perceptions were similar and relatively high at all four clinics.

The inability to see clinical areas or other staff members may hinder staff members from having a better awareness of each other. More specifically, the lack of staff members' visibility of clinic areas may cause staff members to spend additional time finding each other. For instance, Emory Clinic B had a low level of staff seeing overall clinic area (8.3%) compared to other clinics. During the data collection visit of the clinic, two incidents were observed where staff members were trying to find someone. An RN was looking for a rooming nurse, asking around, "Where is this nurse? Did you see a short nurse? I hear her. Where is she?" Interestingly, the nurse the RN was looking for was shouting to the RN,

“Hey! I am here,” but they could not see each other. Another incident involved a missing patient. Three staff members were looking for the patient who could not find a way back to the exam rooms after using the restroom. A rooming nurse asked around, “Where is my patient? I can’t find him.” The nurse recruited help from other staff members, stating, “Let me check this side of the clinic.”

Another story that illustrates the necessity of staff seeing other staff members’ workstations was shared by a provider in Mayo Clinic C. The provider described his experience of working in previous and current clinic layouts. The clinic moved into a new facility, and the previous layout had separate workspaces for providers and rooming nurses that were at a distant from each other. The provider felt like he spent 5-10% of his time looking for nurses in the previous layout while he spends 3% of his time in the current layout. He stated that finding staff was easier in the current layout where the team area is shared by all team members.

Another negative outcome of the lack of visibility to other staff workstations is that staff members are not aware of other staff members, especially those who have shared workload. This may hinder their workflow (e.g., complicate the process or delay the patient care). For instance, in Mayo Clinic C, a huddle room in the middle of the shared team area blocks visibility of staff members from other staff members and overall clinic area. A staff member stated in the survey, “With the U shape for where staff sits, there are days I don't ever see those on the other side.” The difficulty of seeing the other side of the team area and the clinic hinders staff members to have an awareness of clinic status and other staff members who share workloads. An RN shared her experience of not knowing the fact that an ambulance had arrived in the clinic for a patient in the waiting area. She said it was okay

for that instance since the situation was under control, but she emphasized the desire and the need of nurses to know what is occurring in the clinic, since situations can escalate very quickly. Another instance highlighting the negative consequence of the lack of visibility was shared by a rooming nurse in Clinic C. She explained her way of using electronic medical records (EMR) to communicate with other rooming nurses who share the workload of taking care of nurse-only-visit patients. Since not every rooming nurse can see all the other nurses, they cannot tell what other nurses are doing and whether they are available for the nurse-only-visit patients. Therefore, they developed their own way of communicating via EMR to indicate the status of the patients. Also, in Mayo Clinic D, a rooming nurse shared her experience of delayed patient care. Rooming nurses in Clinic D share their workload and collectively take care of their patients in each team. However, the nurse stated that it is hard to know whether other rooming nurses in the other area are available since nurse work areas are separated and not visible. She said that one day a receptionist approached and told her, "You know a patient has been waiting for more than 20 min," to which she replied, "Really? What are other LPNs on that side doing?" These examples illustrate the necessity of being able to see other staff members and clinic area to have better situation awareness, which in turn helps to avoid waste of time searching for each other, failure of providing urgent care to patients in need, complications or delays in the care processes.

In summary, the qualitative observations and interviews illustrated the necessity of visibility of clinic areas and other staff members for staff members' situation awareness. The lack of staff members' visibility of clinic areas and other staff members caused staff

members to spend additional time looking for other staff members or patients and hindered staff members' workflows, complicating the care process or delaying patient care.

2.4.3 Workstation Visibility and Communication

2.4.3.1 Staff members in clinics where they can see more staff workstations have higher perceptions of timely and frequent communication

While communication patterns of staff members were measured with multiple methods, first, staff perceptions (timely (4-item) and frequent (1-item) communications) and its associations with staff seeing other staff workstations in the clinic were analyzed. As illustrated in Table 4 and Figure 7, the staff communication perceptions, both frequency and timeliness show positive linear relationships with staff seeing other staff workstations visibility levels. Clinic D with higher visibility level shows higher communication perception levels, and Clinic B with lower visibility level reports lower communication perception levels. Multiple analyses were conducted to statistically test the differences in communication perceptions between clinics and the linear relationships between communication perceptions and staff seeing other staff workstations.

Table 4 – Results of the staff visibility variable and communication perceptions per clinic.

Variables	Clinic A	Clinic B	Clinic C	Clinic D
Staff visibility: Staff members seeing each other's workstations				
Number of workstations	14	33	21	53
Average number of visible other workstations	4.4	7.0	5.7	27.5
Total number of other workstations	13	32	20	52
Ratio	34.1%	22.0%	28.6%	53.0%
Staff Teamwork: Communication perceptions				
Staff responses (N)	14	15	19	35
Communication frequency (1 item) Mean	4.43	4.07	4.53	4.89
Communication frequency (1 item) SD	0.51	0.70	0.51	0.32
Timely communication (4-item) Mean	3.96	3.53	3.86	4.03
Timely communication (4-item) SD	0.80	0.35	0.67	0.51

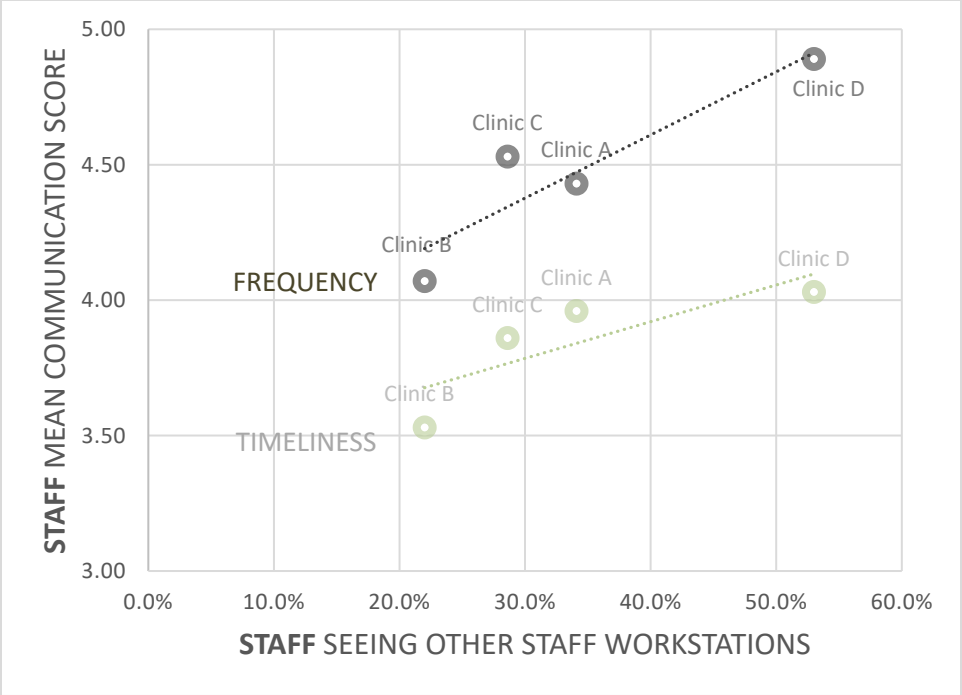


Figure 7 – Staff seeing other staff workstations and two communication perception constructs. Staff at clinics with higher levels of staff seeing other staff workstations report that they have more timely and frequent communication.

For frequent communication perception scores, the nonparametric Kruskal-Wallis H test reported that there were statistically significant differences in the mean scores between the clinics, $\chi^2(3) = 24.387$, $p < .001$, with a mean rank teamwork score of 35.07 for Clinic A, 24.60 for Clinic B, 39.08 for Clinic C and 53.81 for Clinic D. Subsequently, post-hoc pairwise comparisons were conducted to identify clinics that show differences using Dunn's (1964) approach with a Bonferroni correction. The post-hoc analysis revealed statistically significant differences in frequent communication scores between Clinic D and Clinic B (adjusted $p<.001$), and Clinic D and Clinic A (adjusted $p=.023$). The clinics explain about 27% of the total variance of the frequent communication perception scores according to the effect size ($\eta^2=.271$). In other words, the clinics showed different levels of frequent communication perceptions, and the magnitude of the phenomenon was large. Furthermore, the positive linear relationship between the staff-staff visibility and frequent communication perception was found to be significant, r=.922, p=.039 (1-tailed).

The mean scores of the timely communication were found to have statistically significant differences between clinics as shown in the result of the Kruskal-Wallis H test, $\chi^2(3) = 9.901$, $p = .019$, with a small effect size ($\eta^2=.087$). The mean rank timely communication score of four clinics are 45.89 for Clinic A, 24.87 for Clinic B, 43.47 for Clinic C and 46.99 for Clinic D. The post-hoc pairwise comparison analysis revealed statistically significant differences in timely communication scores between Clinic D and Clinic B (adjusted $p=.014$). The linear relationship was not statistically supported according to the Pearson correlation analysis, r=.816, p=.092 (1-tailed).

In summary, this study found positive linear relationships between staff visual connections and communication perceptions. Staff members in clinics where they can see

more of other staff workstations reported higher perceptions of timely and frequent communication. The magnitude of the phenomena was larger for communication frequency than timely communication.

2.4.3.2 Clinics or spaces with higher workstation visibility levels do not necessarily support staff members to have more frequent communications

While the overall staff-workstation visibility levels were found to have positive associations with communication perceptions, no specific effect of the overall visibility level was found on observed communication frequency. Clinics, where staff members could see more of staff workstations, did not have more frequent communications between staff members. According to the behavior mapping observation results, 12% to 15% of observed core team members (providers, rooming nurses, and RNs) talked to each other on average in all four clinics (13.6% for Clinic A, 11.8% for Clinic B, 14.3% for Clinic C, and 15.5% for Clinic D). No statistically significant differences between clinics were reported. Furthermore, when all staff members are considered, 40%, 32%, 46%, and 31% of all observed staff members participated in interactions in Clinic A, Clinic B, Clinic C, and Clinic D, respectively, not showing a specific relationship with the overall visual connection levels between staff members in the four clinics.

Since overall staff-workstation visibility levels of clinics did not differentiate communication frequency of core staff members, finer levels of visibility were further investigated. One visibility variable is levels of workstations at each location: how many workstations are visible at certain locations. The assumption was that more communications might occur at locations where more workstations were visible, as Rashid

et al. (2006) reported. However, the behavior mapping observation results illustrated that this assumption is not supported. The observed staff communications did not occur at clinic areas where they could see more staff workstations (See Appendix D for locations of observed staff communications at each clinic).

2.4.3.3 Instead, staff talk near their workstations

The observed staff communications showed localized patterns. Most observed staff communications occurred around workstations, which are not locations where more staff workstations are visible in the clinic. Further investigations of behavior mapping communication data revealed that staff members mostly (76% - 92%) talked with each other while sitting at their workstations. As noted, behavior mapping observations recorded postures of individuals whether they are standing, sitting, or walking. It was found that 92%, 78%, 76%, and 83% of observed communications involved at least one sitting staff member during the interactions in Clinic A, Clinic B, Clinic C, and Clinic D, respectively (Table 5). This corresponds to a finding that 70% of collaboration occurs at workstations (HermanMiller, 2014).

Table 5 – Observed communications and staff postures.

Posture	Clinic A	Clinic B	Clinic C	Clinic D
Total number of observed staff communications	130	82	79	125
Communications of all standing/walking staff members	11	18	19	21
Communications involving a mixture of sitting and standing/walking staff members	49	28	36	49
Communications of all sitting staff members	70	36	24	55
Sitting included ratio (at least one sitting staff communication instances/all observed communication instances)	92%	78%	76%	83%

There are two possible explanations for the localized pattern of communications around workstations. First, it is possible that staff members need to access computers, screens, or electronic information while talking to each other. During the behavior mapping observations, devices (desktop, laptop/tablet, paper, medical devices, phone/cell, printer/fax, and other) that staff members actively used were recorded. The behavior mapping data revealed that 27% to 38% of observed communications involved computers, which are nearly the half of the communications involving at least one sitting staff member (Table 6). As Luff, Heath, and Greatbatch (1992) noted, screen-based systems localize staff members to screens constraining locations of collaborations.

Table 6 – Observed communications and engaged devices.

Device	Clinic A	Clinic B	Clinic C	Clinic D
Total number of observed staff communications	130	82	79	125
No computer involved communication instances	81	51	58	81
Computer involved communication instances	49	31	21	44
Clinic staff use laptop (Y/N)	Yes (PR)	No	No	No
Computer involved ratio (Computer involved communication instances/all observed communication instances)	38%	38%	27%	35%

Another possible reason for the workstation-centered communications is that staff members (need to) talk to each other at a close distance for privacy. When a staff member is sitting at their workstation, other staff members may approach them and talk in a close distance (especially for patient-related information) rather than yelling at each other or talking across team areas. The average distances between talking staff members were found to be 5.24 ft., 5.71 ft., 4.80 ft., 4.79 ft., in Clinic A, Clinic B, Clinic C, and Clinic D, respectively. This distance falls under social space of individuals, near the edge of personal

space (Hall, 1966). As shown in Figure 8, very few communications occurred beyond 12 ft., which is stated as the public distance between individuals.

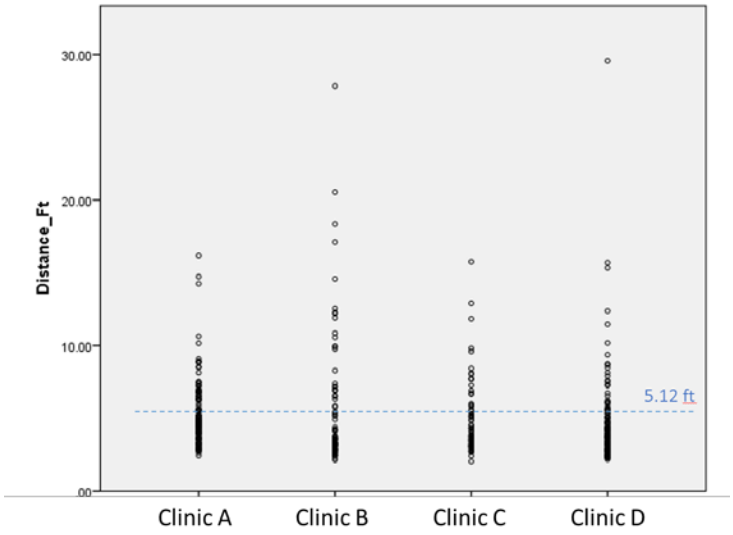


Figure 8 – Scatter plot of communication distances (ft.) in each clinic. Staff members talked to each other in a close distance (on average 5.12 ft. across clinics).

2.4.3.4 Visual connections between workstation clusters increase communication frequency

Most communications were observed at staff workstations. Then, what would influence staff members' communication frequency around their workstations? Would visual relationships between workstations effect staff communication frequency? In order to investigate the relationship between workstation visual connections and observed communication frequency, the localized patterns of communication between staff members were further analyzed.

Communications between specific roles (e.g., providers and rooming nurses) might occur more often since it is necessary to talk to each other due to the care process, and the nature of the tasks. For instance, providers and rooming nurses are required to talk to each

other to debrief, and staff members sharing their workload such as RNs or rooming nurses may need to talk to each other to update the progress and status. While the previous analyses considered all staff members as one group of inhabitants, the subsequent analyses differentiated groups of staff members according to their roles to explore and control the effect of roles on communication patterns.

For role-specific communication patterns, this analysis regarding workstation clusters focused on providers, rooming nurses, and RNs as core team member roles among various roles of staff members in the clinics. While other roles of team members such as extended care team members, call nurses, receptionists, and administrative personnel play critical role as team members, in most clinics they do not share team areas with the core team members. They use separate areas such as front desk, administrative office, consultation rooms, or call rooms as their main work area.

The three staff roles generate six combinations of communication counterparts (e.g., providers-to-providers, and providers-to-rooming nurses). Table 7 illustrates observed communication frequencies and visual connection levels between workstation clusters per each communication counterpart.

The specific role combination of communication frequency ratio was calculated as "observed talking role-specific individuals" to "total observed role-specific individuals" and represented as percentage values. For instance, in Clinic A, a total of 174 providers were observed during 78 observation periods and among those observed providers, 69 of providers were talking to other providers (69/174*100 = 39.7%).

The visual connections between role-specific workstations are categorically defined in three levels: workstations are almost not visible to each other (level 1),[1] workstations are partially visible to each other (level 2),[2] and most workstations can see each other (level 3).[3] Clinics where the same roles of staff members are clustered together (Clinic A, Clinic B, and Clinic D) provide level 3 visibility between staff members with the same role. However, visibility between staff members with different roles varies in the three clinics depending on the spatial layout of team rooms. Clinic D provides partial visibility (level 2) between providers and RNs but provides level 1 visibility (almost not visible) between rooming nurses and other roles due to the locations of LPN stations in the team room. In Clinic B, staff members of each role share a team area. A provider-area and a rooming nurse-area are physically located next to each other but visually disconnected by walls or partitions (level 1). An RN-area is located separately from other team areas. While Clinic A separates team areas like Clinic B, the separated team areas are visually connected providing partial visibility between staff members with different roles (with an exception of provider-RN combination). Clinic C, on the other hand, locates staff members with different roles with a concept of pods, providing visual connections between staff members with different roles assigned to each other, and providing partial visibility between staff members with same roles.

[1] Almost not visible (level 1): their workstations are in separated workstation clusters, and they are almost not visible to each other without walking or turning around.
[2] Partially visible (level 2): their workstations are in separated workstation clusters, and they can see some of each other role's workstations at their workstations including when they stand up, or move within their cluster.
[3] See each other (level 3): specific roles of staff members' workstations are clustered together, sitting next to each other with direct visual connections. Not necessarily all staff members of the roles are located all together. May be separated into multiple clusters of workstations.

Table 7 – Descriptive results of teamwork outcome measurements.

	Clinic A	Clinic B	Clinic C	Clinic D
Visibility levels between role-specific workstations (Level 1 = almost not visible [a], level 2 = partially visible [b], level 3 = see each other [c])				
Provider-Provider	3	3	2	3
RN - RN	3	3	2	3
ROOM - ROOM	3	3	2	3
Provider - RN	1	1	3	2
RN - ROOM	2	1	3	1
ROOM - Provider	2	1	3	1
Observed communications between specific staff roles [d] (=observed talking role-specific individuals/observed role-specific individuals * 100)				
Provider-Provider	39.7%	10.4%	3.7%	17.0%
Observed number of providers	174	154	54	224
Observed number of provider-provider interactions	69	16	2	38
RN - RN	7.0%	36.8%	17.0%	23.2%
Observed number of RNs	142	76	47	177
Observed number of RN-RN interactions	10	28	8	41
Rooming nurse - Rooming nurse	18.8%	14.9%	13.6%	43.5%
Observed number of rooming nurses	170	289	88	239
Observed number of ROOM - ROOM interactions	32	43	12	104
Provider - RN	1.9%	0.0%	14.9%	3.2%
Observed number of providers and RNs	316	230	101	401
Observed number of provider - RN interactions	6	0	15	13
RN - Rooming nurse	4.2%	3.8%	14.8%	1.7%
Observed number of RNs and rooming nurses	312	365	135	416
Observed number of RN - ROOM interactions	13	14	20	7
Rooming nurse - Provider	10.2%	5.0%	21.8%	4.3%
Observed number of providers and rooming nurses	344	443	142	463
Observed number of ROOM - Provider interactions	35	22	31	20

Note. [a] *Almost not visible (level 1): their workstations are in separated workstation clusters, and they are almost not visible to each other without walking or turning around.*
[b] *Partially visible (level 2): their workstations are in separated workstation clusters, and they can see some of each other role's workstations at their workstations including when they stand up, or move within their cluster.*
[c] *See each other (level 3): specific roles of staff members' workstations are clustered together, sitting next to each other with direct visual connections. Not necessarily all staff members of the roles are located all together. May be separated into multiple clusters of workstations.*
[d] *Only providers, RNs, and rooming nurses are considered generating six different combinations of communication counterparts.*

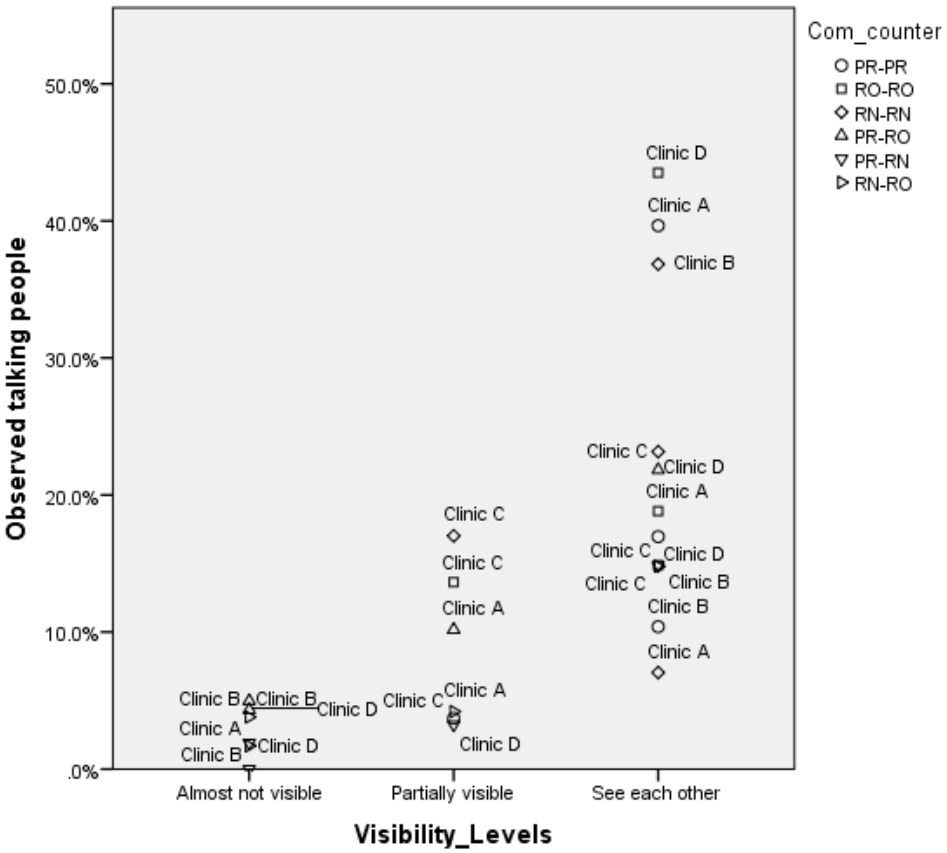


Figure 9 – Observed frequency of communications in relation to clinics, communication counterparts, and categorical visibility levels. More communications occur between workstation clusters with more visual connections regardless of staff roles.

In order to statistically compare the communication frequency ratio means between the visual connection levels, the differences between clinics and roles were first analyzed. No statistical differences were observed in the frequency of communications between clinics ($\chi^2(3) = .620$, $p = .892$), and between specific roles of communication counterparts ($\chi^2(5) = 10.740$, $p = .057$) according to the nonparametric Kruskal-Wallis H tests. Intra-role communications such as provider-provider (17.6%) or rooming nurse-rooming nurse (22.7%) occurred slightly more frequently compared to inter-role communications such as provider-rooming nurse (10.3%), but the differences were not statistically significant.

The only factor that reported statistically significant differences in communication frequency levels was the categorical levels of visual connections between workstation clusters. The nonparametric Kruskal-Wallis H test revealed that there were statistically significant differences in frequency of communications between visibility levels, $\chi^2(2) = 14.632$, $p = .001$, with a mean rank communication frequency of 4.83 for Almost not visible (level 1 (n=6)), 9.67 for Partially visible (level 2 (n=6)), and 17.75 for See each other (level 3 (n=12)). Furthermore, the post-hoc pairwise comparison analysis reported that the frequency of communication levels of the visibility level 3 (See each other) is statistically significantly higher than that of the level 1 visibility (Almost not visible) (adjusted p=.001). The categorical visibility levels were found to have a large effect size (η^2=.602) explaining 60.2% of the total variance.

With these findings, a follow-up question arose: are staff members in visibility level 3 layouts talking to each other due to their close distance to each other, not because of the visual connections? The definition of the visibility levels inevitably confounds the effects of visual connection and distance between workstation clusters in the variable. For instance, workstations that are clustered together (level 3, see each other) provide both visual connections and close distance between workstations. In other words, all role-specific combinations that are defined as level 3 visibility are visually connected and closely located to each other. On the other hand, workstation clusters with visibility levels 1 and 2 are mostly physically separated as different areas having other spaces or rooms in between. There are only two instances of workstation relationships that are adjacently located next to each other in visibility levels 1 and 2: Provider-RN combinations in Clinic B (visibility level 1) and Clinic D (visibility level 2). While the effect of distance cannot

be statistically controlled due to the limited number of sample size (especially for the group of closely located with little visual connections), the two instances highlight the effect of visual connections compared to that of distance between workstation clusters.

In Clinic B, provider-area and rooming nurse-area are closely located next to each other with no visual connections (visibility level 1) between workstation clusters due to a wall and a partition in between. Their communication frequency ratio is low (5.0%). The lack of communication frequency between provider and rooming nurses becomes clearer when the ratio of the four clinics are compared (Clinic C: visibility level 3 and 21.8%, Clinic A: visibility level 2 and 10.2%, Clinic D visibility level 1 and 4.3%). Providers and rooming nurses in Clinic D and Clinic B that have level 1 visibility between their workstation clusters talk to each other very little regardless of the adjacency of their workstations (4.3%, separated and 5.0%, adjacent, respectively). This instance shows that visibility is necessary, and distance is not sufficient enough to facilitate communication frequency between staff members. When there are no visual connections between staff workstations, staff members do not talk to each other frequently even when they are located next to each other.

Another instance in Clinic D illustrates the fact that adjacency is not necessary as well. Provider-area and rooming nurse-area in Clinic D are adjacently located to each other with partial visibility (level 2). Staff members can see the other role of staff members at their workstations especially when they stand up. When workstation combinations that have partial visibility (level 2) across clinics are compared, the adjacent clusters in Clinic D between providers and rooming nurses reported the lowest frequency ratio (3.2%), compared to five other separated instances (on average, 9.7%). The workstation clusters

that are separated showed higher frequency ratio values. One thing to note is that while the workstations are separated, they are on the same floor, often on the same corridor. Distance between workstations within specific threshold (such as on the same floor, corridor or space) might be necessary for more frequent communication as previous studies reported (Allen, 1970; Bolstad et al., 2005; Gunn et al., 2015; Kraut et al., 1988), but putting them next to each other might not be necessary.

While the two instances illustrate the necessity of visual connections (not adjacency) between workstation clusters, the result of another statistical analysis shows that the visual connections between clusters are not only necessary but also increase the communication frequency. When workstation clusters are separated, having even partial visibility supported staff to communicate more. The mean communication frequency ratio values were compared between workstation visibility levels (level 1 and 2) for the clusters that are separated.[4] The nonparametric Kruskal-Wallis H test revealed that there were statistically significant differences in frequency of communications between visibility levels (level 1 and 2), $\chi^2(1) = 3.938$, $p = .047$, with a mean rank communication frequency of 3.60 for the Almost not visible variable (level 1, n=5), and 7.40 for the Partially visible variable (level 2, n=5).

In summary, the effect of visual connections between workstation clusters was found to be significant. Workstation clusters that have visual connections from sharing clusters or being located next to each other showed the highest communication frequency. Staff members did not talk more to specific-role of staff members, and they did not talk

[4] No instances of visibility level 3 are included since all workstation clusters are adjacent to each other for that visibility level.

more to closely located staff members when they did not have visual connections. Providing only adjacency to each other did not support frequent communication, but providing visual connections when the clusters are separated supported staff members to talk more often.

2.4.4 Functional Paths and Communication Frequency

2.4.4.1 Providing visibility of workstations on staff functional paths facilitate communications

While the effect of visual connections between workstation clusters was confirmed, providing visual connections between all possible clusters of workstations is not always feasible depending on the clinic size, layout, and circumstances. An interesting design factor that has a potential to compensate for a lack of visual connections between workstations to increase communication frequency was identified during observations. Providing visibility and accessibility of workstations from staff members' functional paths may increase communication frequency between people whose workstations are not visually connected. As Peponis et al. (2007) noted, movement generates exposure to activities and displays in the workspace supporting awareness. The movement also seems to facilitate communications between staff members.

For instance, in Clinic A and Clinic D, providers' paths to and from exam rooms cover main workstations of rooming nurses. Frequent communications between providers and rooming nurses were observed in Clinic A and Clinic D near or at rooming nurse workstations as the providers were heading to or from the exam rooms to their workstations (Figure 10).

Figure 10 – Communication locations between providers (blue) and rooming nurses (orange) (Left: Clinic A, Right: Clinic D). Providers talked to rooming nurses near nurse workstations on their way to or from exam rooms, as marked on the figure with squares.

Furthermore, this design strategy may work effectively for collaboration between providers and extended care members such as specialists or care coordinators. In many clinics including Clinic A, Clinic B, and Clinic C, specialists are separately located in assigned consultation rooms where they can see patients outside of the shared team area. As a result, the very low frequency of communications between provider and specialists were observed in the three clinics (1.4% for Clinic A, 0% for Clinic B and Clinic C).

As Gunn et al. (2015) reported, specialists sharing team area with other providers might increase communication frequency. As a care coordinator in Clinic D noted, sharing team area with other providers with clear visibility to the providers enables the more frequent use of face-to-face interactions (90% of the communications), compared to separated offices with no visibility of providers (10% of the communication through face-to-face modes).

For instances where extended care members, such as specialists or care coordinators, need to use separated spaces as their main work area, ways to provide possible encounters are needed. As Allen (2007) stated, people need to see potential communication partners and be reminded of the existence of internal expertise to prompt communications. Overlapped functional paths seem to be one way of providing the possible encounters. For instance, in Clinic A, interesting interaction instances between providers and specialists were observed. Specialists located in the consultation rooms at the end of the clinic came out to the main clinic area to use a copier and a printer. This movement enabled interactions with other providers in their shared provider room or a provider coming out from an exam room (Figure 11). Staff members may collaborate more frequently with team members who do not share main workspaces when they can bump into each other in the clinic.

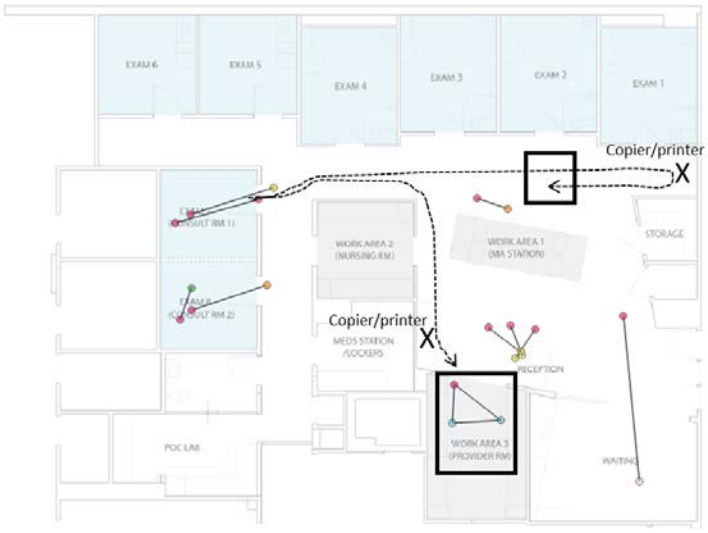


Figure 11 – Communication locations between providers and specialists/care coordinators in Clinic A. Providers and specialists talked to each other when they saw each other in the clinic area away from their workstations.

2.5 Discussion

This study found that the visual attributes of staff members at their workstations were strongly related to staff awareness and communication. First, surprisingly, higher staff visibility levels were not associated with the higher perception of staff awareness. Instead, the study observed instances that highlighted the possible negative consequences of the lack of visibility on staff awareness. When clinic layouts do not support staff members to see the clinic area or other staff workstations, staff members spend additional time searching for each other, and their workflows get obstructed.

Staff members' ability to see other staff workstations predicted both communication perceptions and observed the communication frequency. However, the subjective and objective measurements showed distinct patterns. Clinics that have higher visual connections between staff workstations showed the higher perception of timely and

frequent communications, but the visibility levels of clinics were not associated with observed frequency of communications. Staff members did not talk more often (1) at a clinic that has higher visual connections, (2) to a specific-role of staff members, or (3) to closely located staff members with no visual connections. They talked more frequently to staff members whose workstations are both physically and visually connected to their workstations. Even staff members whose workstations were physically separated from each other talked more often when they were visually connected. This finding corresponds with those from a previous study, which reported that workstations with higher "intervisibility" were associated with more frequent communications (Markhede & Koch, 2007).

This study provides design implications in various scales from clinic layouts to internal layouts of team areas. The location of team areas in relation to the overall clinic predicts awareness of staff members. It is important to locate team areas to maximize visual accessibility to overall clinic area and to other staff members. Team areas, both large team rooms, and multiple separated team areas, especially need to be visually connected for staff communication.

The internal layouts of team areas have significant impacts on communication frequency. More careful consideration of location and relationships between clusters of workstations are required to support communications between staff members. Staff members who need to have frequent communications for patient care need to be located in workstation clusters with visual connections and close distances. Placing workstation clusters in close distance with no visual connections with walls or partitions in between

cannot sufficiently support communication. When all workstations are separated, visual connections between workstations are needed to facilitate staff interactions.

When the visual connection between workstations is not possible, providing visibility to other staff workstations from staff functional paths (by designing the movement of staff members) will promote communication between staff. Providing opportunities to encounter each other during their workday would facilitate communications between those who do not have visual access between their workstations. Relative locations of key touchpoints of the patient care process, such as exam rooms, workstations, labs, and amenity spaces such as copier/printer areas would impact the functional paths of staff members.

This study has several limitations. First, this study did not test the directionality of the relationships in this study. For instance, while strong associations between visual connections and communications were reported and observed, it is hard to discard an alternative explanation that people are seated near with visual connections who they need to talk to and that drives communication, rather than visual connection. Second, only four clinics were empirically investigated. The lack of sample size resulted in a lack of power in several statistical analyses, including correlation analysis. This also disabled further analysis comparing the effect of distance and visibility. Only two instances were highlighted as examples to support the argument. Third, there are some limitations of the outcome measurements. Communication frequency was measured using behavior mapping observations. As the nature of the method (capturing multiple snapshots), it does not capture the full picture of communication patterns, such as communication length. Also, the contents of communications were not recorded during the observations, intentionally.

The communication frequency recorded in this study cannot differentiate patient-related communications or social interactions. Awareness was not objectively measured in this study while communication patterns of staff members were measured in multiple ways. While different patterns of subjective and objective measurement of communications were reported, awareness was measured only subjectively. Lastly, this study did not investigate patients' experience and outcomes. It focused on teamwork of staff members and visibility attributes of staff members. The presence of patients and visual relationships between patients and staff members were not included in this study. How the presence of patients impact staff teamwork and patient experience is a desired topic for future studies.

CHAPTER 3. THE EFFECT OF VISUAL EXPOSURE TO PATIENTS ON PATIENT-RELATED COMMUNICATIONS AMONG STAFF MEMBERS

While the previous chapter investigated how visual interfaces between staff members impact their communication patterns, this chapter brings in the presence of patients to our model of visual interfaces and teamwork in team-based clinics. More specifically, it explores how visual exposure to patients affects staff communication patterns. While this chapter continues investigating staff communication patterns, it focuses on patient-related communications between staff members away from patients.

3.1 Introduction

Patients play a critical role in healthcare settings. Recognizing the importance of teamwork in healthcare settings, many studies have examined communication as a crucial skill for the staff teamwork (Barach & Weinger, 2007; Leonard et al., 2004; Manser, 2009; Wauben et al., 2011). Visibility between team members was found to support interactions between team members in Chapter 2 and in previous studies (Allen, 2007; Heerwagen et al., 2004; Rashid et al., 2009; Sailer et al., 2007, 2009; Wineman & Serrato, 1997). However, not much attention was given to how patients' presence impacts staff communication. More specifically, the impact of visual exposure to the patients on staff communications has not been investigated.

Building layouts determine interfaces between inhabitants and visitors (Hillier et al., 1984). Clinic layouts, especially location and openness of team areas in clinics, regulate

spatial and visual relationships between staff members (inhabitants) and patients (visitors). Opening up staff team area to patients seems to have many values. Patients can see staff members working together, patients might feel the transparency of the staff teamwork, and eventually, patients may perceive themselves as part of the team.

However, the openness of team areas may also have a negative impact on staff communications requiring privacy from patients, called backstage communication (Ellingson, 2003). While backstage communication between staff members (away from patients) is critical for teamwork and achieving teams' patient care goals (Ellingson, 2003), the presence of patients and visual exposure to the patients might discourage staff members from having sensitive communications pertaining to their patients. However, there is no single study investigating the impact of visual exposure to patients on staff backstage communication.

The openness of the team area as it regulates privacy level from patients is an important design aspect determined by the clinic and the team room design. While many healthcare organizations are advocating for team-based clinic layouts, there has been little agreement on how to design clinics to support the teamwork of staff members. The location and the amount of team areas private from patients (backstage) vary between team-based primary care clinics. Team areas at some clinics are completely backstage and private from patients, whereas team areas at other clinics are frontstage, where the staff members are visually exposed and even have interactions with patients. Among many clinics who adopt a team-based approach in their clinic design, this study empirically investigates four team-based primary care clinics. The four clinics were chosen since a) they are associated with healthcare organizations advocating for team-based approach, b) the layouts show a

varying range of team-layout modules reflecting the current debate in the field and c) and their floorplans and access to clinics including staff members and patients were available. By looking at multiple clinics with a range of team room exposure levels, this chapter empirically studies how the visual openness of team area to patients impacts staff backstage communication patterns.

3.2 Theoretical Foundation and Literature Review

3.2.1 Importance of Backstage Communications for Staff Teamwork

Backstage communication is defined as discourse among healthcare practitioners away from patients (Ellingson, 2003). It is Goffman (1959) who first termed "backstage" and "frontstage" in his description of people's social interactions using imagery of the theatre as a metaphor. According to Goffman (1959), frontstage is where people's performances are in play, and backstage is where the suppressed facts make an appearance. Goffman (1959) defines a back region, or backstage as:

> *"a place, relative to a given performance, where the impression fostered by the performance is knowingly contradicted as a matter of course. There are, of course, many characteristic functions of such places. It is here that the capacity of a performance to express something beyond itself may be painstakingly fabricated; it is here that illusions and impression are openly constructed...Here the team can run through its performance, checking for offending expressions when no audience is present to be affronted by them; here poor members of the team, who are expressively inept, can be schooled or dropped from the performance. Here the*

performer can relax; he can drop his front, forgo speaking his lines, and step out of character (p.112)."

As Goffman (1959) noted, backstage plays an important role, providing a buffer area to inhabitants from their visitors. The value of backstage is significant in healthcare settings as well since much teamwork among staff members occurs in the backstage area (Ellingson, 2003). Staff members can relax, teach new staff members, or practice skills out of patients' sight, making it possible to convey competent images to patients by controlling the amount of information exposed to patients.

More importantly, backstage enables private interactions between staff members away from patients (Ellingson, 2002, 2003; Iedema, Long, Carroll, Van Marrewijk, & Yanow, 2010). While backstage communications are often viewed as communications occurring at backstage area in relation to Goffman's definition of backstage region (Lewin & Reeves, 2011; Waring & Bishop, 2010), backstage communications can be defined from the perspectives of user groups, staff and staff communications requiring privacy from patients (Cai, 2012; Ellingson, 2003).

Backstage communication between staff members is critical for staff teamwork. Staff members share information, check clinic progress, build their relationships, and train coworkers by talking to each other (Ellingson, 2003). It helps staff members achieve the teams' patient care goals (Ellingson, 2003). The unplanned information communications between staff members occurring at clinic backstage areas such as hallways and work tables (Ellingson, 2002) allow interprofessional collaboration between staff members (Lewin & Reeves, 2011).

Backstage communications also improve patient care by facilitating frontstage communications between patients and staff members (Ellingson, 2003). More specifically, backstage communications can help staff members gain information about patients before their interaction (e.g., prior knowledge that the next patient is angry), modify agenda for patient encounter (e.g., nurses reporting providers with strategic decisions), and provide practical facilitation of behavioral adjustment for patient encounters (e.g., speaking loud for hard-of-hearing patients) (Ellingson, 2003).

3.2.2 Impact of Built Environments on Backstage Communications

Buildings regulate interfaces between inhabitants and visitors (Hillier et al., 1984). Frontage and backstage areas are related to the distinction of the group of users, inhabitants, and visitors (Cai, 2012). Interactions between inhabitants (clinical staff members) and visitors (patients) can be viewed as frontage encounters, and interactions among inhabitants can be considered as backstage activities.

Unfortunately, there is a general lack of research in investigating the role of built environments on backstage staff communications. A large and growing body of literature has studied frontstage medical care—patient and physician interactions (Atkinson, 1995), but there is lack of understanding of backstage interactions between staff members (Ellingson, 2002). While there are a couple of studies focusing on staff communications in relation to clinical layouts (Gunn et al., 2015; Patterson et al., 2015; Pullon et al., 2016), these studies do not take the existence of patients (visitors) into consideration.

Only two studies have attempted to investigate the role of interface between staff members and patients for backstage communications in medical settings. Cai (2012)

explored and confirmed differences of nursing unit designs in China and the United States. By focusing on communication behaviors, she found that in Chinese nursing units, the ratio of the backstage area to the frontstage area was significantly higher than in U.S nursing units. She suspected that this is due to the preference of preserving "face" of staff members in China. Also, Gum et al. (2012) found the impact of privacy from patients on spontaneous conversations between staff members in their study of three rural hospitals in Australia. They identified the lack of privacy from patients as a factor hindering communications between staff members. A nurse station in one of the hospitals they investigated did not provide privacy for conversations since it was opened to patients without any doors or glass covers. The authors observed nurses lowering their voices or even whispering during their conversations with other staff members.

3.2.3 Team-based Primary Clinic Layouts and Backstage

Recognizing the importance of teamwork in primary clinics (Delva et al., 2008; Jesmin et al., 2012; Samuelson et al., 2012; Shoemaker et al., 2016), the vast majority of primary clinics and organizations are moving toward team-based care (Kennedy & Nordrum, 2015; National Committee for Quality Assurance, n.d.; Schottenfeld et al., 2016; U.S. Department of Veterans Affairs, n.d.). However, there is a lack of understanding of how clinic layouts should be designed to support staff teamwork. Furthermore, various healthcare organizations are each advocating for distinct clinic layouts with different relationships between backstage and frontstage.

For instance, many healthcare organizations including Group Health and Veterans Affairs are adopting a clinic module called "on- and off-stage" module, which disconnects

team areas from patients (U.S. Department of Veterans Affairs, 2016). This module separates the circulation of staff members and patients with dual corridors and dual-entrance exam rooms and makes all team area completely backstage with minimum patient access. On the other hand, Kaiser Permanente and many other clinics are advocating for "open team area" clinic module, focusing on patient experiences and opening up team areas to patients (Bluestein, 2016, March 22). This module makes most (or at least a part) of the team areas visually exposed to patients, blurring the boundary between the frontstage and backstage clinical areas.

While each of these diverse clinic modules and layouts may have its pros and cons, there have been few empirical investigations that look into illustrating the possible impacts of these different layouts on staff teamwork and patient experience.

3.2.4 Research Questions: Exposure to Patients and Patient-Related Communications among Staff Members

When we define backstage as visually private areas from patients for staff members, it is possible for there to be no backstage team areas at certain clinic layouts. The varying degrees of team area privacy levels in various clinic layouts, whether the team areas are frontstage or backstage depending on their visual exposure levels to patients, generate interesting research questions that this study attempts to answer:

- Can staff members have backstage communications at clinics where their team areas are visually exposed to patients (frontstage)?

- If staff members need to have backstage communications, where would they prefer or not prefer? Would they feel comfortable having backstage communications at the frontstage team area public to patients?

The term "backstage communication" can refer to either the communications occurring at physically private space or the communications between staff members (excluding patients). In order to eliminate the confusion of the term, this study refers the backstage communications as patient-related communications between staff members (not necessarily happening at physically private areas). Communications between staff members requiring privacy from patients (backstage communication or patient-related communications) may also happen at frontstage in certain clinics depending on its layout and openness of team areas.

3.3 Methods

3.3.1 Settings

This study investigated four team-based primary clinics which have physical team spaces shared by team members (Figure 12). Among the four clinics, two primary clinics are from Mayo Clinic and two clinics are from Emory Clinic. There are multiple differences between the four clinics beyond the physical spaces, such as sizes, organizations, culture and technology. This study this study acknowledges the differences between the four clinics since the study design does not allow to control the differences. Table 8 provides summary descriptions of the four clinics.

While all four clinics have shared team spaces, the visual relationships between staff members and patients determined by layouts vary. Emory Clinic A has three distinct team areas, and each team room is shared by staff members with the same role (e.g., provider room, and rooming nurse station). These three team areas are visually exposed to both patients and staff members. Emory Clinic B has two teams and five team areas: a nurse workstation and a provider workstation for each team and an RN room for both teams. The nurse workstation and provider workstation are visually exposed to patients, while the RN room is not visible to patients. All workstations at Mayo Clinic C's team area is visually exposed to patients. Mayo Clinic D's team area is less visually exposed to patients, but four LPN stations located near exam room corridors are partially exposed to patients.

3.3.2 Patient-staff visual relationship: Visual exposure to patients

The levels of visual exposure to patients as part of the patient-staff visual relationships were analyzed using VisualPower tool (Lim et al., 2018). The agent of the visibility—patients—is represented by shortest paths from waiting area to all possible exam rooms. The paths are drawn with points with 1 ft. interval. The target of the visibility is staff members in the clinic, represented by a grid of points in clinic area with 1 ft. interval. The visual exposure level at each clinic location was analyzed by counting how many patient points are visible at each clinic point.

Table 8 – Summary descriptions of the four team-based primary care clinics.

	Clinic A	Clinic B	Clinic C	Clinic D
Overall description				
Organization	Emory Clinic	Emory Clinic	Mayo Clinic	Mayo Clinic
Service line	Primary Care	Primary Care	Primary Care	Primary Care
Geographic location	Atlanta, GA	Atlanta, GA	Arcadia, WI	Rochester, MN
Architectural description				
Designed by	A local design firm in Atlanta, GA	A local design firm in Atlanta, GA	A national design firm with local offices	A national design firm with local offices
Year built/renovated	2011	2012	2016	2016
Layout type (Team room)	Open + Closed	Open + Closed	Open + Closed	Closed
Clinic area (centerline, sqft)	2,859	12,179	12,251	21,684
Number of exam rooms	6	28 (14+14)	13	30 (15 + 15)
Operational description				
ERM adopted before the construction	Yes	Yes	Yes	Yes
Size of enrolled patient population	11,400	4,000	4,000	15,000
Number of staff members (Admin not included)	15 totals (4 Providers; 2 RNs; 2 LPNs; 3 MAs; 1 Psychologist; 1 PSC; 1 Nutritionist)	34 totals: 9 Providers, 2 RNs, 7 LPNs; 8 MAs; 1 SW; 6 PSCs; 1 RC)	27 totals (6 Providers; 6 RNs; 5 LPNs; 2 BH; 2 Interpreters; 6 Receptionists)	60 totals (19 Providers; 10 RNs; 13 LPNs; 3 Care Coordinators; 1 SW; 1 Pharm; 1 BH; 3 Patient Appt Coordinators; 9 Clinical Assistants)
Number of teams	1 Team	2 Teams	1 Team	2 Teams
Exam room assignment	Shared by providers	Assigned per provider daily	Per provider	Shared by providers

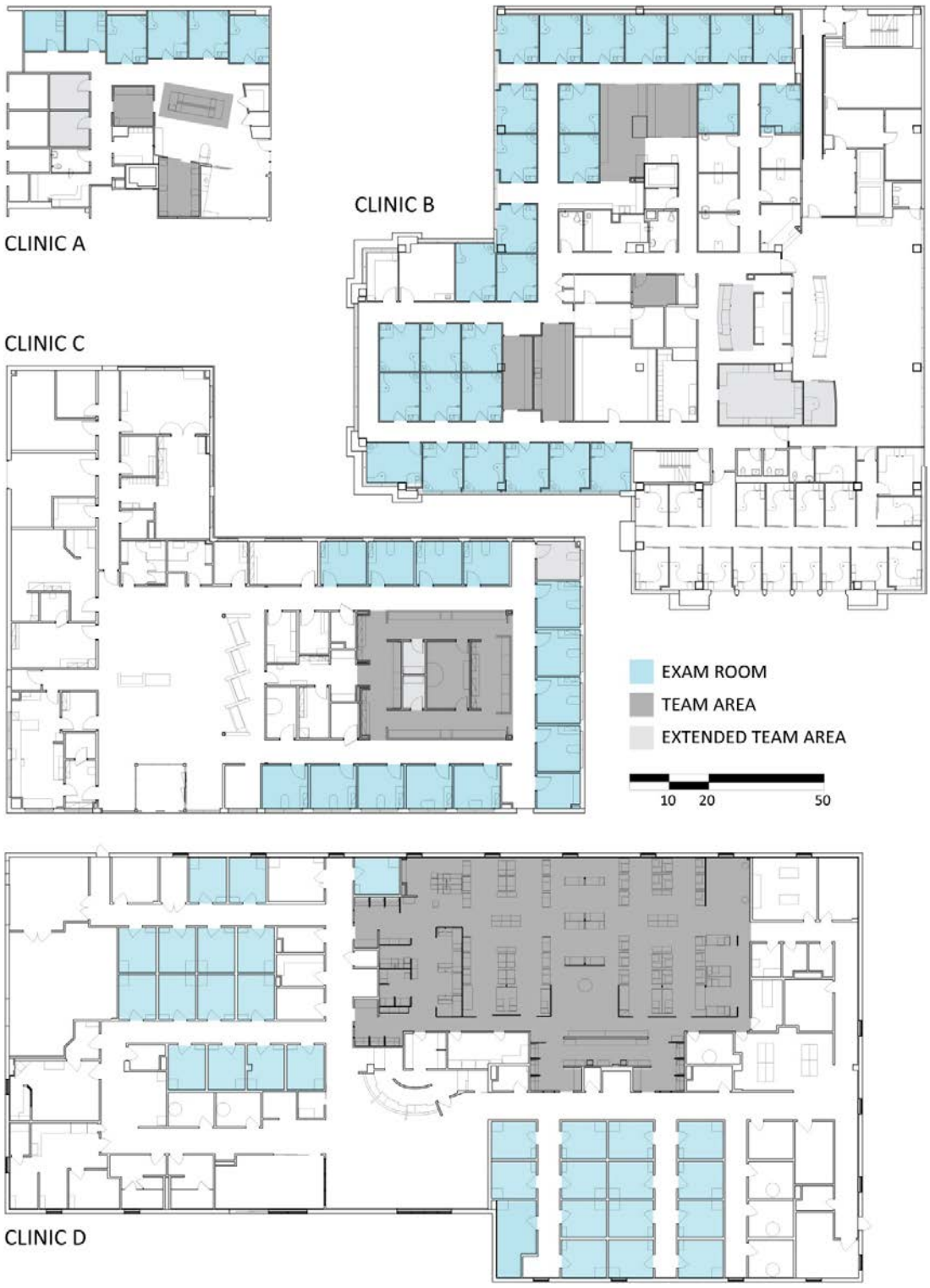


Figure 12 – The layout of the four clinics. Grey areas represent team spaces, and blue areas indicate exam rooms.

3.3.3 Backstage Communication Outcome Variables

This study used multi-methods to understand patient-related communication patterns in clinics. Each clinic was qualitatively observed for 2-3 days, and staff members, managers, administrators were interviewed. All possible staff members were asked to participate in staff survey, which includes two different types of questions for staff perception on patient-related communications.

3.3.3.1 Communication privacy concerns

For staff perception regarding their concerns about having patient-related communications with other staff members, four new items were developed. They were administered to staff members (included response sample size = 83, response rate = 64.3%) and found to be reliable (4 items; $\alpha = .796$). The survey items ask the staff's levels of concerns, or their behavior needs- whether they have to adjust their voice, move into a private space, or check surroundings.

3.3.3.2 Preferred and non-preferred locations for backstage communications

Another set of survey questions asked staff members about locations for private patient-related communications. First, staff members were asked to locate their *preferred* spots for different types of patient-related communications with other staff members, assuming they can go any clinical area. In order to compare preferred and not-preferred locations for such communications, staff members were also asked about locations they would *not* want to have the patient-related communications.

For the preferred and not-preferred locations, four types of backstage communications from Ellingson (2003) were included in the survey: formal reporting or request for clarification/information/opinion; checking clinic progress; training students/fellows/new staff members; and handling interruptions. Respective floorplan of each clinic was included for staff members to mark preferred and not preferred locations for backstage communications. Staff members could mark multiple locations for each question. All the responses were recorded in GIS for further analysis.

3.3.4 Statistical Analysis

Statistical analyses including descriptive statistics, Kruskal-Wallis test, correlation analysis, and multilinear regression analysis were conducted using SPSS 22 (IBM, n.d.).

3.4 Results

3.4.1 Visual Exposure to Patients

The results of the levels of visual exposure to patients are illustrated in Figure 13. The figure depicts visibility levels at each clinic location point using a grey color scheme, representing higher exposure values with darker colors. The exposure levels are compared in two different scales: clinics and spaces. For each unit of analysis (clinic or space), the visual exposure levels are aggregated into mean and ratio (average number of exposed patient points/total patient points) values for comparison.

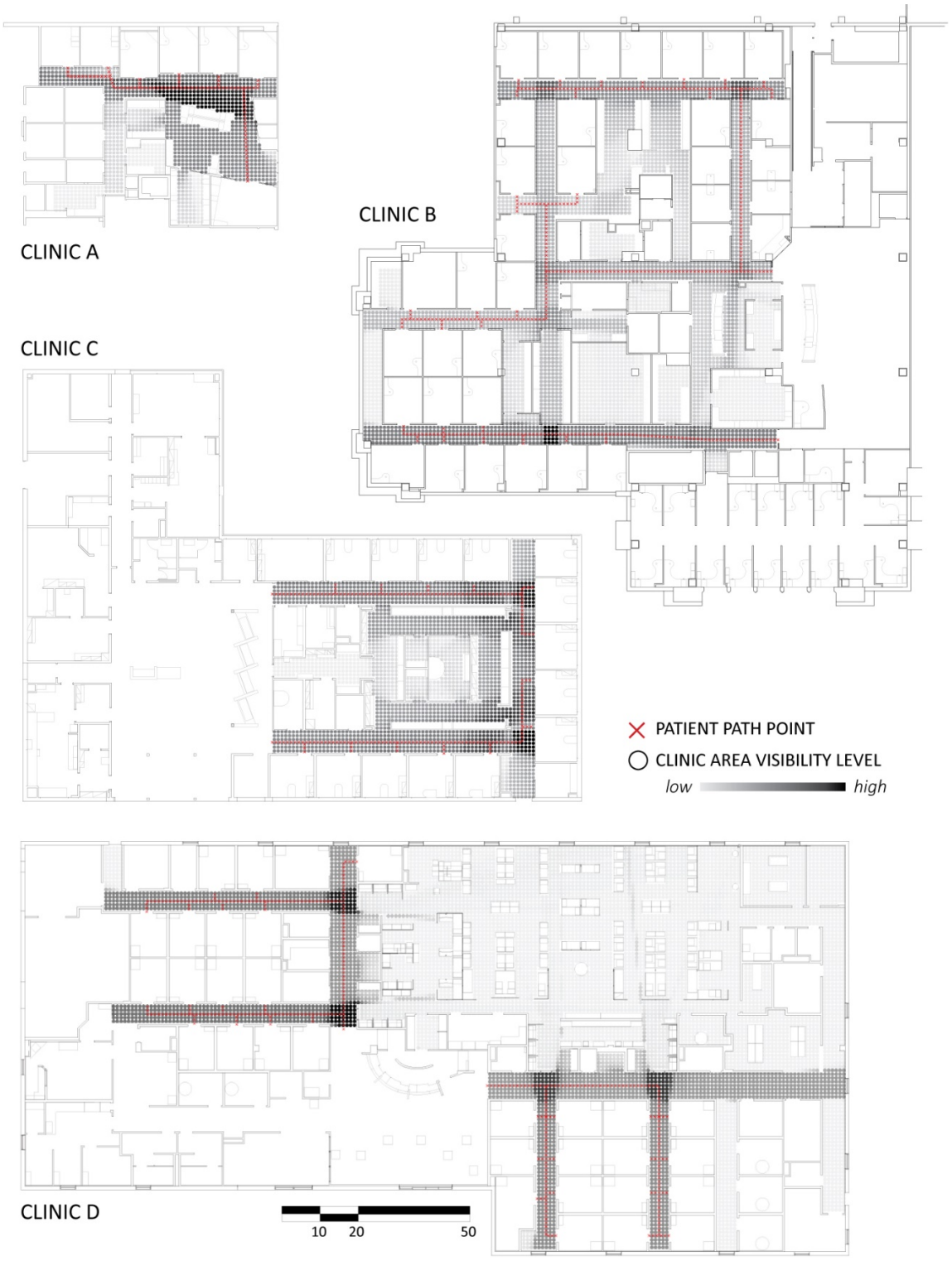


Figure 13 – Visual exposure to patients at each location per clinic. Clinic D and Clinic B show relatively low visual exposure level in team areas, and Clinic A and Clinic C have visually exposed team areas.

3.4.2 Communication Privacy Concerns and Visual Exposure Levels between Clinics

3.4.2.1 Staff in the least exposed clinic have the lowest level of concern

First, staff members' concerns and the visual exposure levels were investigated in clinic levels. A nonparametric Kruskal-Wallis test was conducted to compare the staff concerns for having patient-related communications with other staff members between clinics. The communication privacy concern scores were statistically significantly different between the clinics, $\chi^2(3) = 38.384$, $p < .001$, with a mean rank communication privacy concern score of 63.82 for Clinic A, 58.30 for Clinic B, 46.00 for Clinic C and 24.11 for Clinic D. Multiple pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction. This post-hoc analysis reported that the staff communication concern score of Clinic D is significantly lower than all three clinics, Clinic C (adjusted p=.008), Clinic B (adjusted p<.001), and Clinic A (adjusted p<.001). The clinics explain about 45% of the total variance of the communication privacy concern scores according to the effect size (η^2=.448).

Table 9 – Descriptive results of visual exposure levels and staff survey regarding communication privacy concerns in each clinic.

	Clinic area visual exposure to patients (= patients seeing clinic area)				Staff communication privacy concerns (4-items; α = .796)		
	N (total clinic points)	Mean visible patient points	N (total patient path points)	Ratio	N (staff responses)	Mean	Std. Deviation
Clinic A	1197	47.79	95	50.3%	14	3.95	0.55
Clinic B	4591	50.39	426	11.8%	15	3.68	0.75
Clinic C	2186	74.22	198	37.5%	19	3.20	0.86
Clinic D	7305	20.67	353	5.9%	35	2.27	0.82
Total	NA				83	3.02	1.03

To explore the relationship between visual exposure levels and communication privacy concerns, the aggregated levels of communication concerns along with the visual exposure levels were plotted (Figure 14). While the relationship seems to have a linear trend, the linearity was not statistically supported according to the correlation analysis (r=.642, p=.179 (1-tailed)).

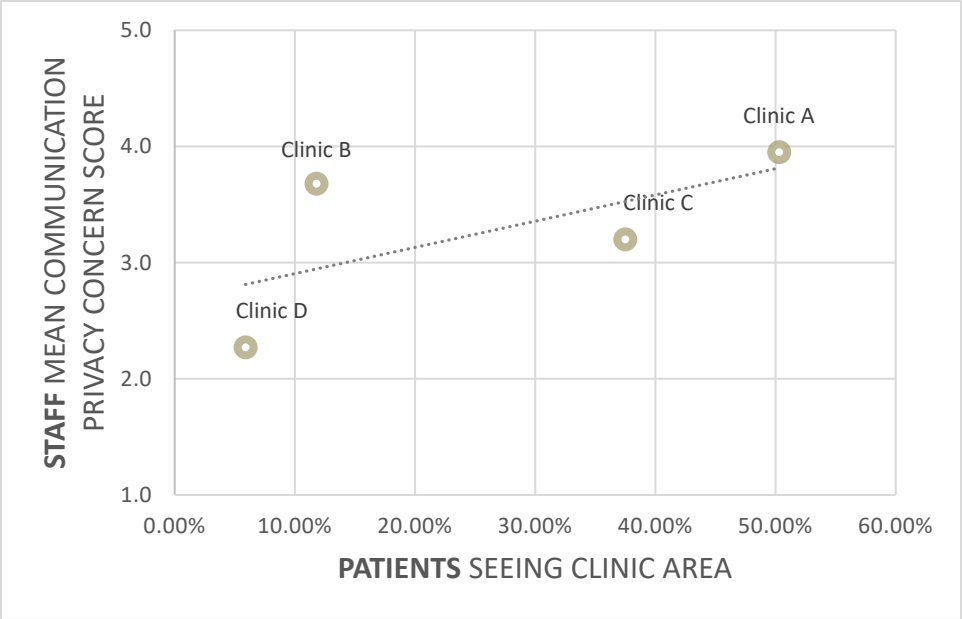


Figure 14 – Visual exposure to patients and staff communication privacy concerns. Staff members in Clinic D with the lowest level of exposure has the lowest level of communication privacy concerns.

3.4.2.2 4.2.2 How the clinic is exposed to patients matters as well

As shown in the plot, Emory Clinic B is an outlier in terms of the linearity of the relationship. The clinic has higher concerns for communication privacy compared to the level of visual exposure to patients. One possible explanation for this aspect is the physical characteristics of the staff team areas in relation to patient corridors. While both Emory Clinic B and Mayo Clinic C adopt a combination of open and enclosed team areas, their

physical attributes toward patient corridors are quite different. As shown in Figure 15, team areas of Emory Clinic B are located perpendicular to the patient corridor, allowing patients to see the back of staff members and monitors of the workstations. Staff members do not have control over the information that are exposed to patients. Furthermore, there are no physical or symbolic barriers between team areas and patient corridors. On the other hand, Mayo Clinic C's team area is facing patient corridors, with glass partitions between team areas and patient paths (Figure 16). The monitors and the pertinent information are therefore not exposed to the patients.

This openness aspect of team areas in Emory Clinic B seems to exacerbate staff members' concerns. For instance, a manager of the clinic stated during the interview that providers are concerned about patients passing by their workstations. She described that when providers dictate their notes at workstations using voice recorders, they mumble worrying about other patients hearing sensitive patient information, generating lots of errors. Another survey supports staff concerns regarding the openness of team area. A rooming nurse stated, "I would make the workstations more private. There should be doors to prevent patients from entering workstations and hearing confidential info."

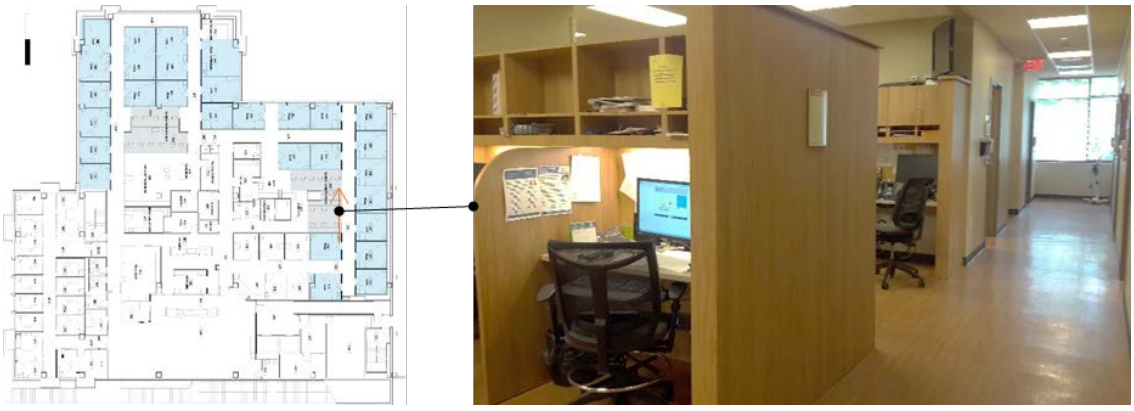


Figure 15 – A picture of staff team area from a patient corridor in Emory Clinic B. Monitors are exposed to patients in corridors with no clear boundary between team areas and corridors.

Figure 16 – A picture of staff team area from a patient corridor in Mayo Clinic C. Staff members are facing patient corridors through glass partitions between team areas and corridors.

3.4.3 Preferred and Non-Preferred Locations for Patient-Related Communications and Visual Exposure Levels per Space

All the responses for preferred and non-preferred locations for patient-related communications in each clinic were recorded in GIS accordingly. As a result, a total of 426 preferred locations (94 in Clinic A, 40 in Clinic B, 113 in Clinic C, and 179 in Clinic D)

and 605 non-preferred locations (99 in Clinic A, 87 in Clinic B, 121 in Clinic C, and 298 in Clinic D) were collected and recorded.

In order to identify the visual attributes of preferred and non-preferred locations, the spaces in each clinic were divided according to their program of use (e.g., office, team area, rooming nurse workstations, corridors, etc.). Since this study is focusing on staff behavioral patterns in relation to the presence of patients, the study included public clinic areas and staff workspaces, leaving out waiting areas and exam rooms. A total of 96 spaces (11, 31, 15, 39 spaces for Clinic A, Clinic B, Clinic C, and Clinic D, respectively) were included in the analyses.

For the spatial variable, mean exposure levels per space were calculated. The preferred and the non-preferred locations in waiting areas, exam rooms, or other non-clinical spaces were excluded. As a result, a total of 387 preferred locations and 419 non-preferred locations are further analyzed. The frequency of preferred and non-preferred selections was calculated per each space, which then was adjusted for the size of each space using the number of clinic points used in the visibility analyses (each point represents 1 sqft area). The data from the four clinics were not pooled together for further analysis (unless stated otherwise) since the levels of patient exposure values vary between clinics (e.g., the maximum value of the exposure ratio of spaces is 0.86 in Clinic A, while it is 0.23 in Clinic D). The summary data of each space is described in detail in Appendix E.

The results of the adjusted preference and non-preference values along with average visual exposure levels per space per clinic are illustrated in subsequent figures (Figure 20, Figure 21, Figure 22, and Figure 23). The figures show both adjusted preferred (positive)

and adjusted non-preferred (negative) values per space, in the order of visual exposure levels of the spaces (high exposure to low exposure). The figures demonstrate some interesting general tendencies across clinics. Interestingly, the two constructs, preferred locations, and non-preferred locations show distinct patterns. High adjusted preference values are centered on team spaces, regardless of the visual exposure levels, and high adjusted not-preferred values are located mostly at highly exposed areas at all four clinics, with some outliers in Clinic B. These different tendencies of preferred and not-preferred locations were further analyzed and supported statistically in the following subsections.

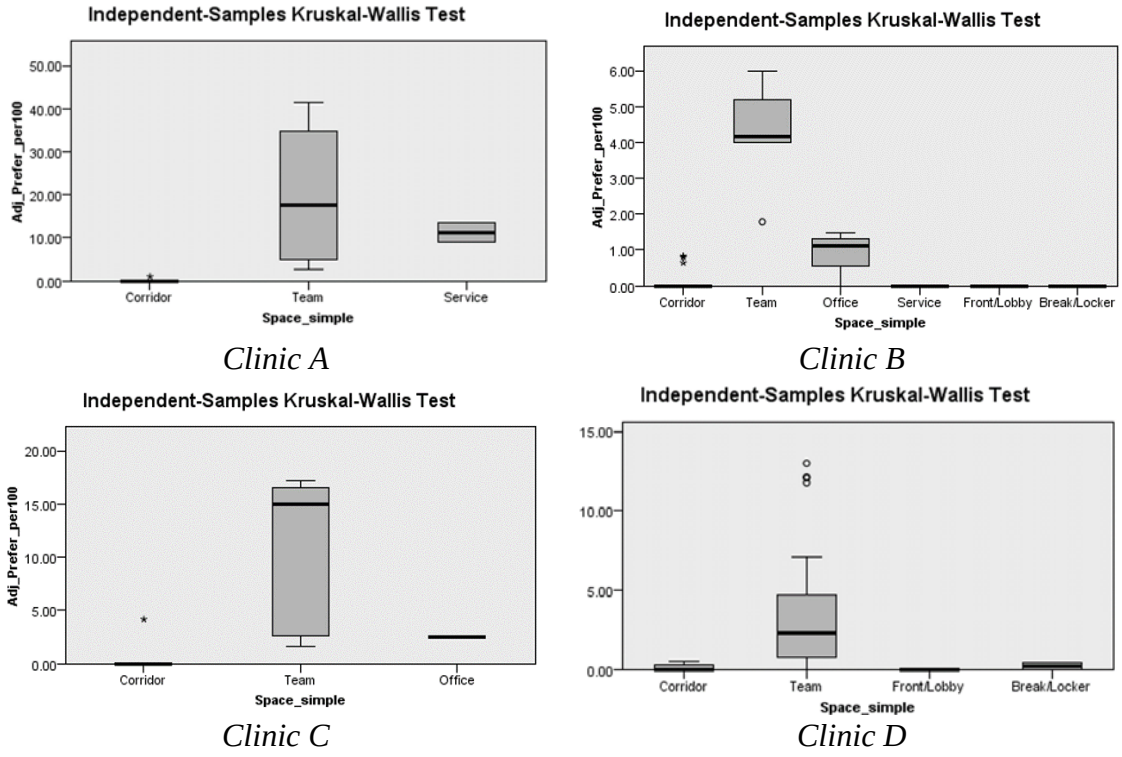
3.4.3.1 Staff members prefer talking about patients at team areas

First, the preferred locations of patient-related communications at each clinic was investigated. There are three main factors that may impact the preference values: clinics (e.g., Clinic A, B or C), space programs (e.g., Team space, corridor, or office), and exposure levels (e.g., level 1, 2, or 3). The impacts of the space programs and the exposure levels were analyzed using two different statistics.[5] Since the space program is a nominal variable, the differences between programs at each clinic were tested using a non-parametric Kruskal-Wallis H Test. The relationship between exposure levels and the preference values were analyzed using a non-parametric correlation test, Spearman's rho.

For the space programs, all four clinics showed statistically significant differences between programs showing the highest level of preference frequency at team spaces (Clinic A: $\chi^2(2) = 7.857$, $p = .020$, Clinic B: $\chi^2(5) = 21.006$, $p = .001$, Clinic C: $\chi^2(2) =$

[5] As noted, clinics are not pooled together, and analyses were conducted four times for each clinic. Non-parametric tests were used since the data were not normally distributed.

9.150, p =.010, and Clinic D: $\chi^2(3) = 15.099$, p =.002) (Figure 17). Furthermore, post-hoc multiple pairwise comparisons using Dunn's (1964) procedure with Bonferroni correction reported significant differences between the team space and other spaces (Clinic A: between corridor areas and team spaces (p=.034), Clinic B: between corridor areas and team spaces (p<.001), and between service areas and team spaces (p=.016), Clinic C: between corridor areas and team spaces (p=.009), and Clinic D: between corridor areas and team spaces (p=.002)).



Clinic A *Clinic B*

Clinic C *Clinic D*

Figure 17 – Kruskal-Wallis Test result of four clinics. The preference levels are the highest at team spaces compared to other programs in all four clinics.

While the effect of the program spaces was significant (team areas were the most preferred locations for patient-related communications), the effect of visual exposure levels of spaces was not significant at all clinics according to the correlation analysis (Table 10). Only Clinic C showed a statistically significant negative linear relationship between visual

exposure levels and preferred frequency (r=-.535, p=.040 (2-tailed)), and the test results of the other three clinics were not significant.

Furthermore, in order to consider the impact of space programs and visual exposure levels together, a multiple regression analysis was conducted by pooling all clinics together. Both visual exposure levels and preference/non-preference frequency data were transformed. First, visual exposure levels were proportionally transformed to have the maximum value of 1 (the most visually exposed space = 1). The preference/non-preference frequency data were log transformed after adding a constant of 1 (in order to include the values of zero) for its normality.

The multiple regression model statistically significantly predicted log transformed adjusted preference frequency values with a small size effect, $F(3, 92) = 3.746$, $p = .014$, adj. $R^2 = .080$.[6] Among three variables (clinics, space programs, and visual exposure levels), only the visual exposure levels variable was found to be a statistically significant predictor with a negative standardized coefficient $\beta = -.362$, $p = .005$. The regression coefficients and the standard errors are described in Table 11. Visual exposure levels of spaces (slightly) matter for where staff prefers to talk about patients. This may explain why staff members preferred talking in team areas over talking in other program areas,

[6] Not all assumptions of the test were met. There was no evidence of multicollinearity, as assessed by correlation values larger than 0.7 and tolerance values greater than 0.1. There was no leverage values greater than 0.2, and values for Cook's distance above 1. There was one value of studentized deleted residuals slightly greater than +3 standard deviations (3.009) and it was included in the analysis. The residuals are approximately normally distributed, as assessed by a Q-Q plot. Linearity between independent and dependent variables were observed. However, there might be correlated errors, according to a Durbin-Watson statistic of .874, and heteroscedastic residuals according to a plot of studentized residuals versus unstandardized predicted values. While some assumptions were violated, the test results are reported in this study in order to compare the relationship patterns between preference and non-preference frequency values.

especially over corridors. As shown in Figure 18, team areas in all clinics are visually less exposed to patients compared to corridors, which is inevitable since the origin of patient visibility is the patient corridors.

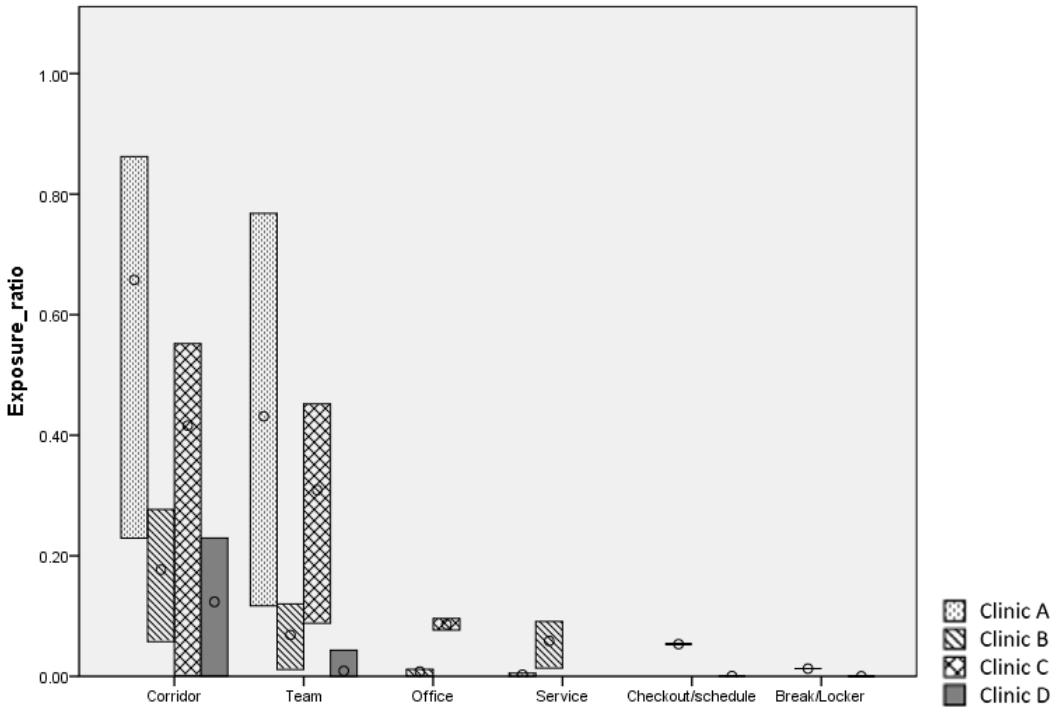


Figure 18 – Visual exposure levels (max, min, and mean) per space at each clinic. Team areas are less exposed to patients compared to corridor areas.

To further investigate the impact of visual exposure levels on preference frequency values, a multiple regression analysis with only team areas across four clinics was conducted. The multiple regression model was statistically significant, $F(2, 35) = 4.827$, $p = .014$, adj. $R^2 = .171$,[7] and reported interesting results. Within team areas, the

[7] Most assumptions of the test were met, with some assumptions on the edge of the normal range. The Durbin-Watson statistic was 1.464, slightly lower than the normal range of 1.5 to 2.5. There were three leverage values greater than 0.2 (0.224, 0.223, and 0.208), but they were not excluded from the analysis. There was no values of studentized deleted residuals greater than +3 standard deviations, and values for Cook's distance above 1. Linearity between independent and dependent variables were observed. The residuals are approximately normally distributed, as assessed by a Q-Q plot. There was homoscedasticity, according to a plot of studentized residuals versus unstandardized predicted values. There was no evidence of multicollinearity, as assessed by correlation values larger than 0.7 and tolerance values greater than 0.1.

effect of visual exposure levels was not statistically significant (p = .751). Staff members did not consider levels of visual exposure to patients for having patient-related communications in team areas.

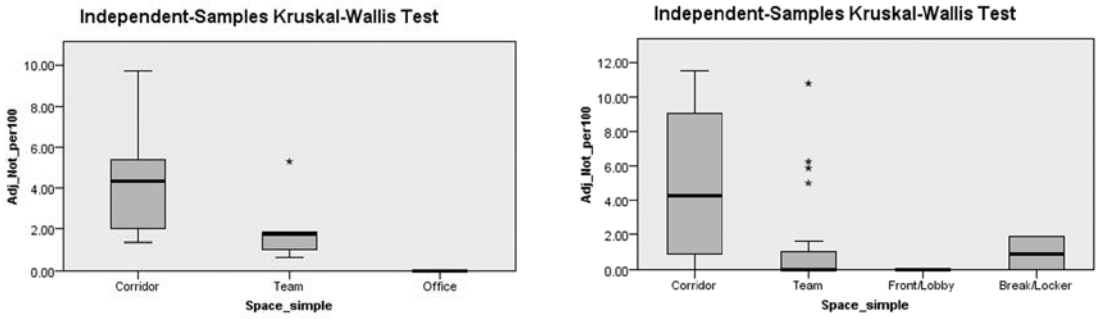
In summary, staff members preferred talking about patients at team areas in clinics where it is visually less exposed to patients compared to corridor areas, but within team areas, the level of visual exposure to patients did not impact where staff members preferred to talk about patients.

3.4.3.2 Staff members do not prefer talking about patients in visually exposed areas

Similarly, the effect of the space program and the exposure levels were investigated for each clinic using two statistics: a non-parametric Kruskal-Wallis H Test for comparing non-preference levels between space programs, and Spearman's rho correlation analysis for testing a linear relationship between exposure levels and non-preference values.

Interestingly, while the effect of space programs, especially team areas, on preference frequency values were found to be significant at all four clinics, only two clinics showed statistically significant differences in non-preference frequency values between space programs (Clinic C: $\chi^2(2) = 7.228$, p =.027, and Clinic D: $\chi^2(3) = 10.419$, p =.015) (Figure 19). Furthermore, according to post-hoc multiple pairwise comparisons, the non-preferred frequency of team spaces in Clinic C was neither statistically higher nor lower compared to other program areas. Clinic D is the only clinic where corridor spaces showed higher non-preference values than team areas (p=.012) among the four clinics.

On the other hand, when the linear relationship between visual exposure levels and non-preference frequency values were investigated with correlation analysis, three clinics, Clinic A, Clinic C, and Clinic D, showed statistically significant positive relationships (Table 10). Emory Clinic B did not show statistically significant linear relationships between visual exposure levels and both preference and non-preference frequency values.



Clinic C *Clinic D*

Figure 19 – Kruskal-Wallis Test result of four clinics. The non-preference levels are not statistically significant at all four clinics. Corridor spaces show statistically higher non-preference values compared to office spaces in Clinic C and to team spaces in Clinic D.

Furthermore, two multiple regression analyses (all spaces, and only team areas) were conducted with transformed data to see the impact of clinics, space programs, and visual exposure levels on non-preference frequency values (Table 11). The two models both reported statistically significant results predicting log transformed adjusted non-preference frequency values, $F(3, 92) = 15.875$, $p < .001$, adj. $R^2 = .320$ for all spaces (n =

96),[8] and $F(2, 35) = 11.695$, $p < .001$, adj. $R^2 = .366$ for only team areas (n = 38).[9] In both models, only the visual exposure level variable statistically significantly predicted the log-transformed adjusted non-preference frequency values ($\beta = .650$, $p < .001$, and $\beta = .718$, $p < .001$, respectively). In other words, regardless of spatial programs, staff members did not prefer talking about patients in visually exposed areas.

Table 10 – Results of nonparametric correlations (Spearman's rho) between visual exposure ratios and adjusted preference/non-preference.

Clinic	Number of spaces	Adjusted selection frequency	Correlation Coefficient	Sig. (2-tailed)
Clinic A	11	Adj. Preference	-.600	.051
		Adj. Non-preference	.758**	.007
Clinic B	31	Adj. Preference	-.266	.148
		Adj. Non-preference	.115	.537
Clinic C	15	Adj. Preference	-.535*	.040
		Adj. Non-preference	.876**	.000
Clinic D	39	Adj. Preference	-.053	.749
		Adj. Non-preference	.573**	.000

** Correlation is significant at the 0.05 level (2-tailed).*
*** Correlation is significant at the 0.01 level (2-tailed).*

[8] All assumptions of the test were met. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.089. There was no evidence of multicollinearity, as assessed by correlation values larger than 0.7 and tolerance values greater than 0.1. There was no leverage values greater than 0.2, values for Cook's distance above 1, and values of studentized deleted residuals greater than +3 standard deviations. There was homoscedasticity, according to a plot of studentized residuals versus unstandardized predicted values. The linearity between independent and dependent variables were observed and the residuals are normally distributed, as assessed by a Q-Q plot.

[9] Not all assumptions of the test were met. The Durbin-Watson statistic was 1.320, slightly lower than the normal range of 1.5 to 2.5. There were three leverage values greater than 0.2 (0.224, 0.223, and 0.208), but they were not excluded from the analysis. There was one value of studentized deleted residuals slightly greater than +3 standard deviations (3.143) and it was included in the analysis. There was no values for Cook's distance above 1. There was no evidence of multicollinearity, as assessed by correlation values larger than 0.7 and tolerance values greater than 0.1. There was homoscedasticity, according to a plot of studentized residuals versus unstandardized predicted values. The linearity between independent and dependent variables were observed. The residuals are approximately normally distributed, as assessed by a Q-Q plot.

Table 11 – Summary of multiple regression analysis.

Dependent variable (N and adj. R^2)	Variable	Unstandardized regression coefficient	Standard error of the coefficient	Standardized coefficient	Sig.
Log transformed Adj. Preference Frequency (N=96, adj. R^2 = .080)	Constant	.678	.197		
	Clinic	-.063	.041	-.163	.131
	Programs	-.009	.042	-.025	.830
	Visual exposure	-.417	.145	-.362	.005*
Log transformed Adj. Preference Frequency, only team rooms (N=38, adj. R^2 = .171)	Constant	1.196	.297		
	Clinic	-.172	.077	-.425	.031*
	Visual exposure	.099	.311	.061	.751
Log transformed Adj. Non-Preference Frequency (N=96, adj. R^2 = .320)	Constant	-.073	.154		
	Clinic	.051	.032	.143	.122
	Programs	.021	.033	.064	.528
	Visual exposure	.682	.113	.650	.000*
Log transformed Adj. Non-Preference Frequency, only team rooms (N=38, adj. R^2 = .366)	Constant	-.105	.223		
	Clinic	.055	.057	.159	.345
	Visual exposure	1.010	.233	.718	.000*

*Note. * $p < .05$*

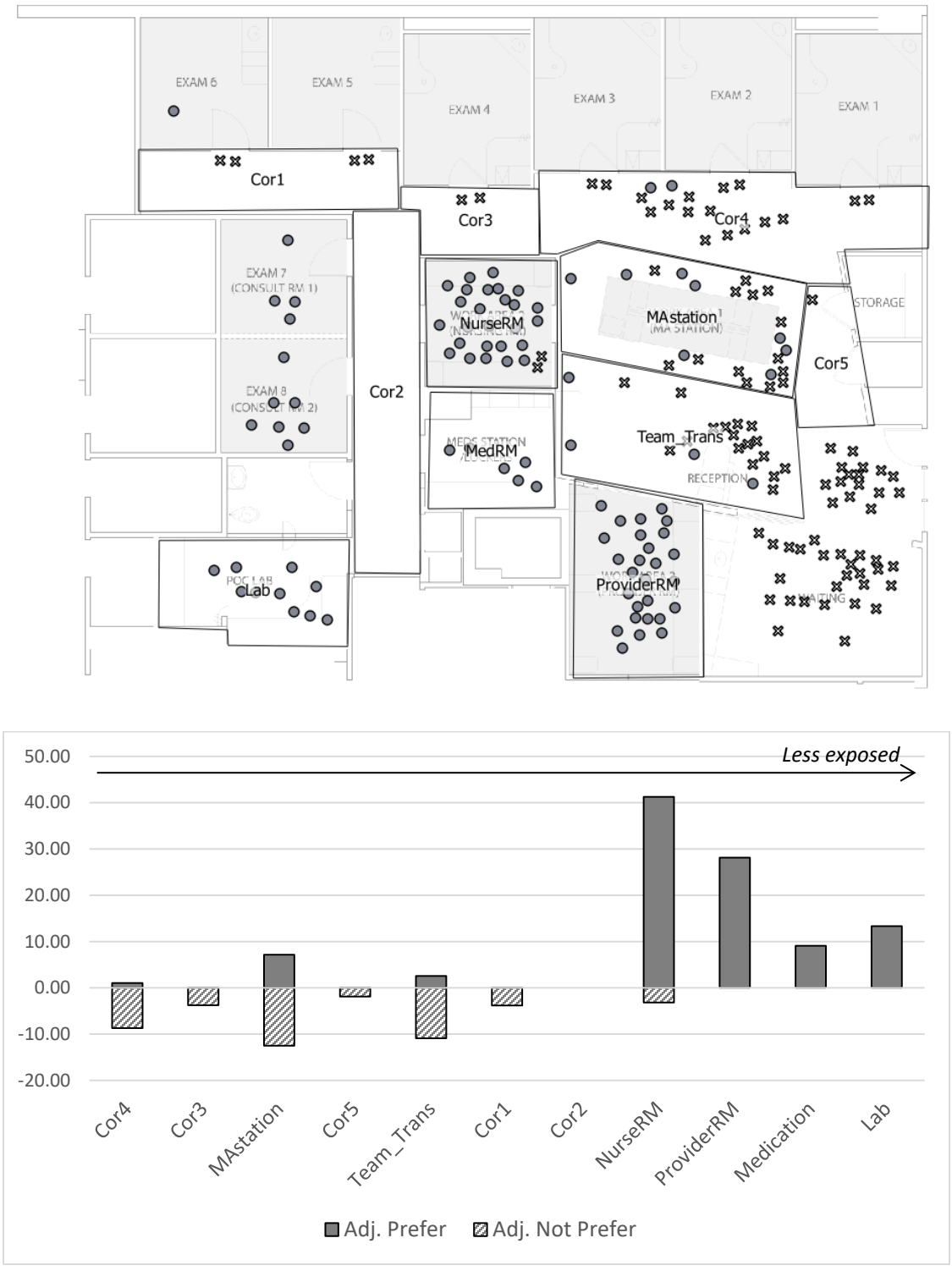


Figure 20 – Reported preferred (o) and non-preferred (x) locations for backstage communications (above) and adjusted preference and non-preference per space, rank ordered (below) at Clinic A. Visually exposed MA station and Team transit area has lower preference values and a mixture of preference and non-preference.

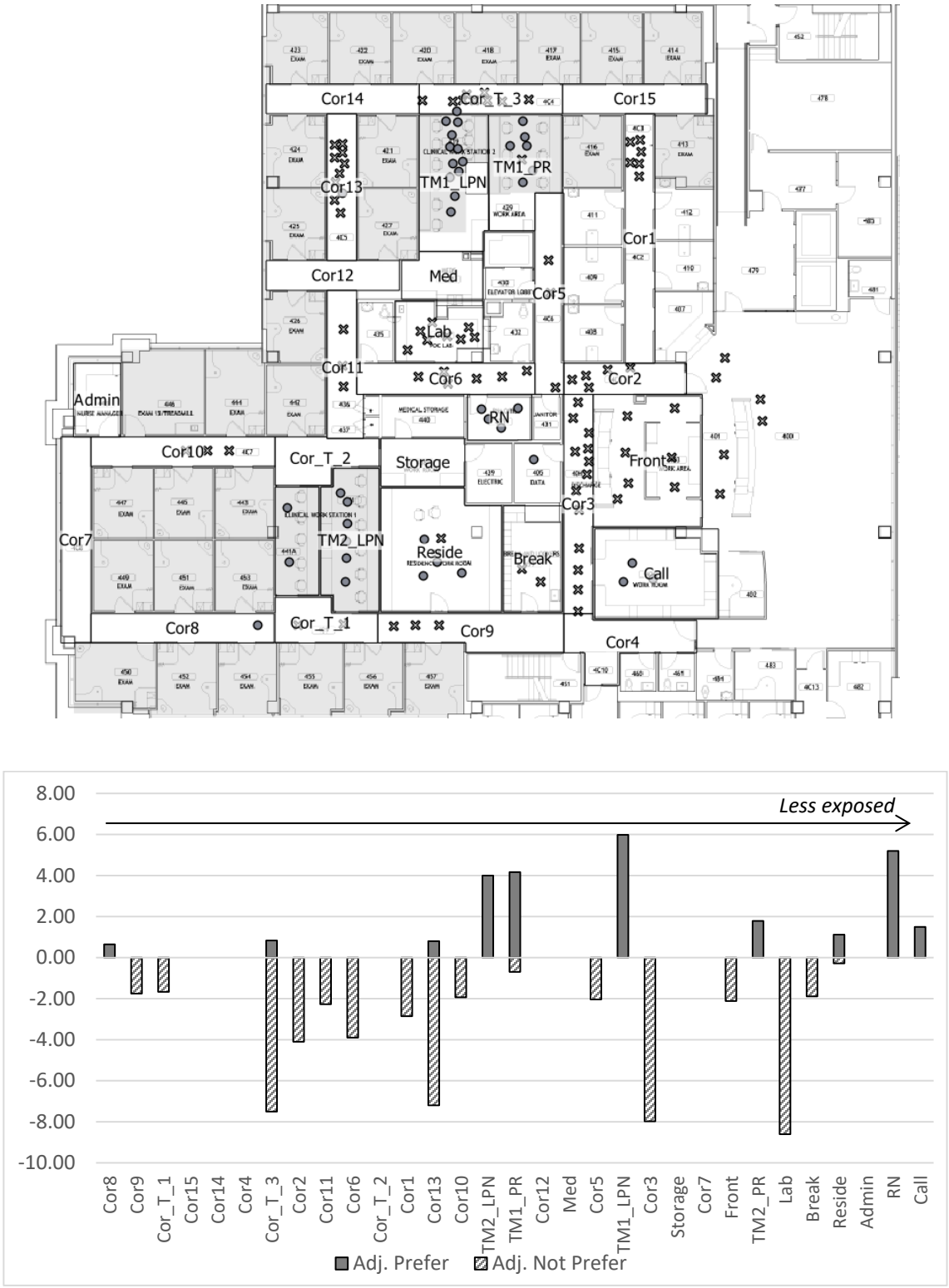


Figure 21 – Reported preferred (o) and non-preferred (x) locations for backstage communications (above) and adjusted preference and non-preference per space, rank ordered (below) at Clinic B. No clear trends are shown in Clinic B, but Team1, provider area has both preferred and non-preferred values.

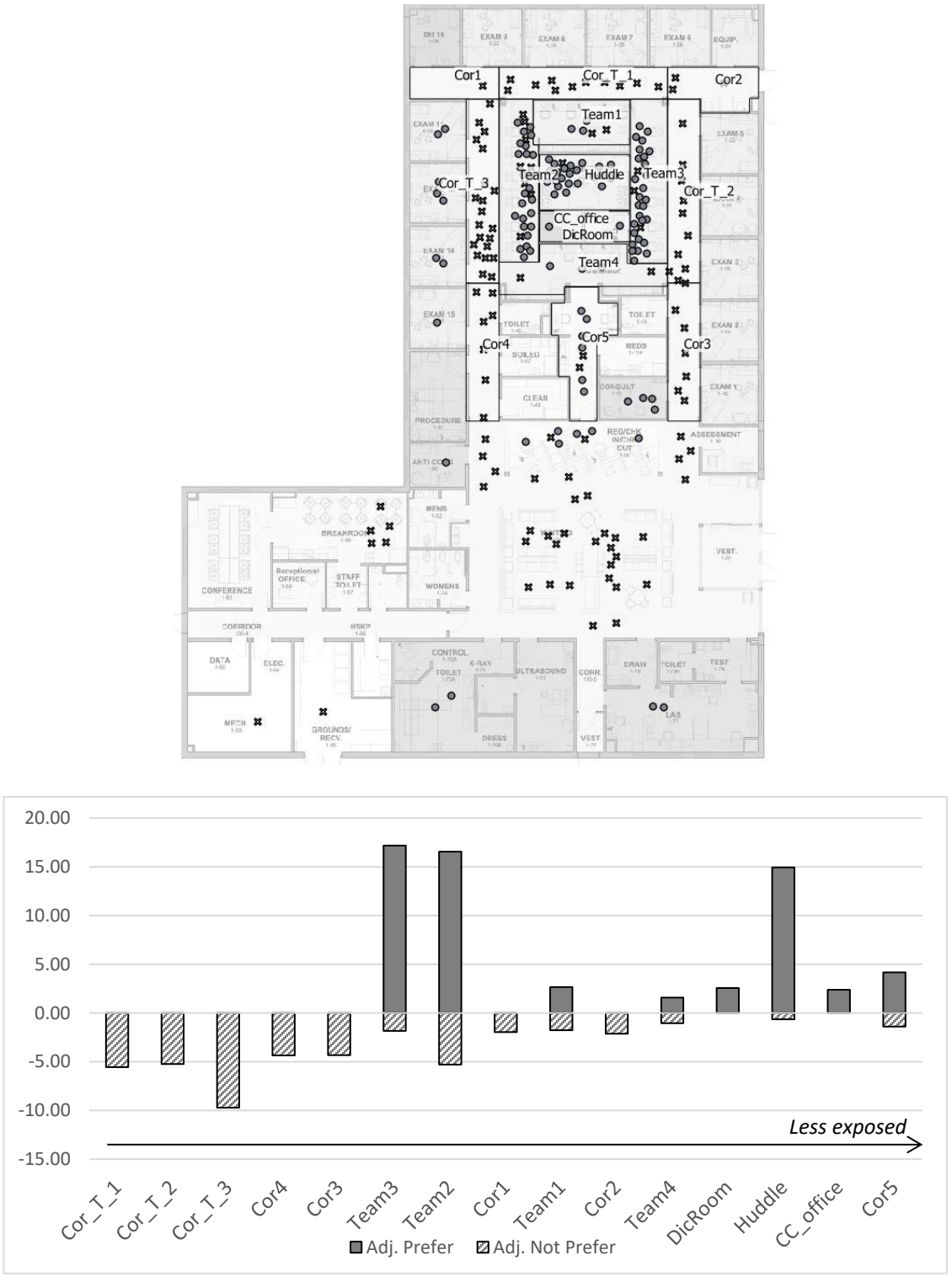


Figure 22 – Reported preferred (o) and non-preferred (x) locations for backstage communications (above) and adjusted preference and non-preference per space, rank ordered (below) at Clinic C. Visually exposed team areas (Team 2 and Team 3) has a mixture of preference and non-preference values.

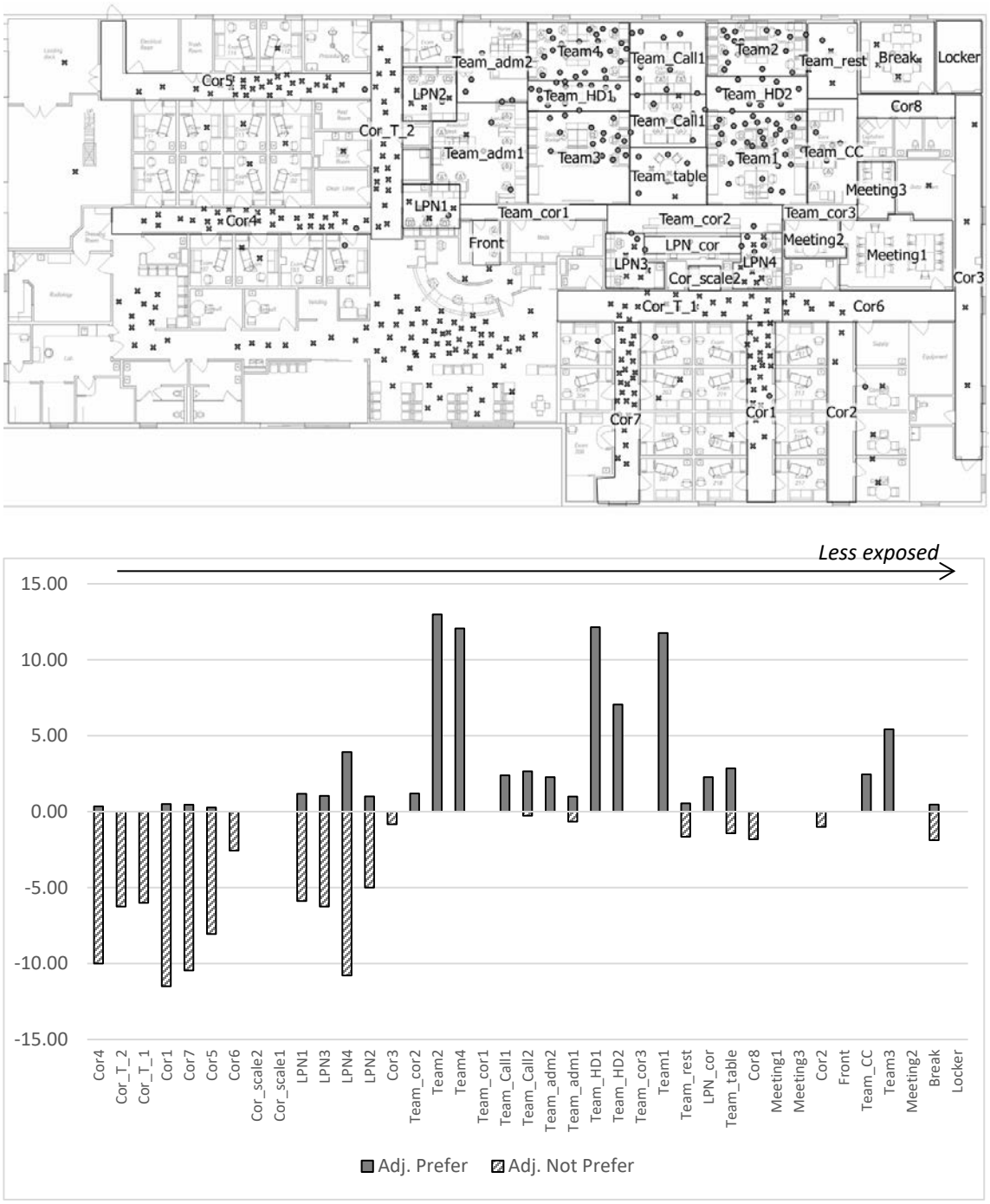


Figure 23 – Reported preferred (o) and non-preferred (x) locations for backstage communications (above) and adjusted preference and non-preference per space, rank ordered (below) at SE clinic. There is a clear distinction between preferred and non-preferred spaces for staff backstage communications. Visually exposed areas are not preferred, and less exposed areas are preferred. Visually exposed team areas (LPN 1, 2, 3, and 4) have high values of non-preference and the mixture of preference and non-preference values.

3.4.3.3 Visually exposed team areas have contradictory preference patterns

Statistical analyses revealed two different patterns of patient-related communications. Staff members preferred talking in team areas which are visually less exposed to patients in the clinic, but within team areas, the level of visual exposure did not matter. On the other hand, staff members did not prefer talking in visually exposed areas, such as corridors in the clinic and visually exposed areas within team spaces. In summary, staff members prefer talking in team areas, and they do not prefer talking at visually exposed areas.

Then a question arises: what about team areas visually exposed to patients? For instance, the nurse station in Clinic A and the LPN stations in Clinic D are visually more exposed to patients compared to other team spaces. These visually exposed team areas show lower preference values compared to other workstations, and a mixture of preferred and non-preferred instances (Figure 24). This indicates that at these visually exposed team areas, there is a lack of agreement between staff members' preferences towards having patient-related communications.

However, it is possible that staff members have no choice other than talking about patients at those team spaces. For instance, as noted in Chapter 2, many ad-hoc communications between rooming nurses and providers occurred at the nurse stations both in Clinic D and Clinic A. The functional paths of providers between their workstations and exam rooms enabled interactions with rooming nurses at LPN stations. Staff members who do not prefer talking about patients at those visually exposed nurse stations may have to

participate in the communications due to its locations and necessity. This may impose a layer of environmental stress on staff members.

Figure 24 – Backstage communication patterns at visually exposed team areas. Visually exposed team areas highlighted with red lines have the mixture of preference and non-preference values.

3.5 Discussion

While the previous chapter investigated overall communication patterns of staff members in relation to the visual connections between staff members, this chapter focused on backstage communication of staff members. This chapter reported interesting patterns at the four clinics in relation to the visual interface between staff members and patients. First, staff members in clinics with less visual exposure to patients reported lower concerns about having backstage communication. The four clinics did not show statistically significant linear relationships, but the clinic with the lowest visual exposure level, with its

layout using enclosed team room, had the lowest levels of concern. Not only the amount of the visual exposure but also the way the clinic area, especially team area, is exposed to patients were found to influence staff members' concerns about communication privacy.

Furthermore, across clinics, staff members preferred team areas and not preferred visually exposed spaces for their backstage staff communications. The preference pattern corresponds to the finding of the previous chapter that most staff interactions occurred around their workstations in team areas and talked frequently to other staff members who were visually and physically connected. The visual exposure to patient levels seemed to affect non-preference patterns more than preference patterns. The distinct patterns of preferred and not preferred locations identified a possible environmental stress factor imposed on staff members. Team areas that are visually exposed to patients had lower preference values compared to other team areas, and also had a mixture of preference and non-preference frequency values. There is lack of agreement between staff members whether they would like to or not like to talk with each other at those visually exposed team areas in the clinic.

The findings of this study provide practical design implications. While this study found the lowest communication privacy concerns at the least visually exposed clinic, it is not conclusive enough to advocate for a specific layout (such as the enclosed team clinic layout), since other possible positive impacts of the open team areas as well as unique cultural and organizational factors have not been not investigated. Instead, the findings of this study emphasize the importance of careful attention to visual interfaces between staff members and patients, especially "how" to open the team areas to patients. The visual interfaces between staff members and patients are determined by various design

components, such as the location of team areas, walls/glasses around them, the location of waiting rooms or exam rooms, the location of patient/staff corridors, and circulation of patients and staff members, and so on. As illustrated in the case of Emory Clinic B, opening up team areas (even just a little bit) without careful considerations, such as monitors or backside of the staff workstations are exposed to patients in corridors, can increase staff members' concerns about communication privacy requiring them to adjust their voice, or to look around whether patients are around or not.

Another design implication this study highlights is the importance of "where" to visually expose to patients in clinics. Staff members in visually exposed team areas tend to have lack of agreement in terms of having staff communications, possibly causing discomfort to staff members. Team areas or other staff work areas where frequent and significant staff communications need to occur privately from patients should not be visually exposed to patients.

This study has limitations in both spatial attributes and patient/staff outcome measurements. First, the study focused on visual relationships between staff members and patients quantified as amounts of visual exposure to patients. While there are other environmental and situational factors such as auditory features, this study did not investigate the effect of such factors. Furthermore, this study did not explore relationships between built environments and patient outcomes. Instead, this study focused on process measurements such as awareness and communication patterns. In addition, as mentioned briefly, other possible values or outcomes of openness of team areas are not studied. While the openness of clinic area to patients causes staff members to be concerned about having backstage communication, it may positively impact patients on their experience. By seeing

staff members working together in clinics, patients might perceive the transparency of staff teamwork and feel like part of the team. Future studies empirically studying such other values of openness and providing a holistic view of the impact of openness of the clinic on patient and staff experience are expected.

CHAPTER 4. THE EFFECT OF VISUAL ACCESS OF TEAM AREA ON OVERALL TEAMWORK PERCEPTION OF STAFF AND PATIENT

While the previous two chapters examined the staff teamwork skills from the staff members' perspectives, this chapter investigates how visual interfaces between the staff members and the patients impact both the staff members' and the patients' teamwork perception.

4.1 Introduction

The transformation of primary care clinics into team-based and patient-centered care models is nationally promoted with various programs and recognition (Jackson, Powers, Chatterjee, & et al., 2013; National Committee for Quality Assurance, n.d.; Patient-Centered Primary Care Collaborative, n.d.; Schottenfeld et al., 2016). In these models, along with the importance of teamwork in primary care (Delva et al., 2008; Jesmin et al., 2012; Samuelson et al., 2012; Shoemaker et al., 2016), the significance of patient-centered approach is clearly stated (Patient-Centered Primary Care Collaborative, n.d.; Schottenfeld et al., 2016).

While the patient is a critical stakeholder of the team-based primary care clinics (Ficarra, 2010; Patient-Centered Primary Care Collaborative, n.d.; Schottenfeld et al., 2016), the "patient perspective" in teamwork is often neglected (B. Henry et al., 2013; Mercer et al., 2008; Shoemaker et al., 2016). Most studies solely focus on the perspective

of the caregivers, and Shoemaker et al. (2016) found only one study that explored the patients' perspective on teamwork in their extensive literature review.

Patients' perception of staff teamwork is meaningful. Patients view lack of interpersonal skills and communication as potentially 'unsafe' aspects of their care and consider 'lack of coordination' or 'mis-communication' as a possible safety threat (Rathert, Brandt, & Williams, 2012). Patients view the lack of communication among providers problematic (B. Henry et al., 2013), and patient perception of teamwork may impact overall patient satisfaction (B. W. Henry, Rooney, Eller, Vozenilek, & McCarthy, 2014). Conveying a collaborative image to patients and enabling them to perceive their staff members working as a team may have positive impacts on patients.

Buildings regulate spatial interfaces between inhabitants and visitors (Hillier et al., 1984), and convey organizational values and professional image to both inhabitants and visitors (Baldry, 1997; Bitner, 1992; Parish, Berry, & Shun Yin, 2008). Likewise, by regulating what staff members or patients can see and experience, clinic layouts may help them perceive organizational value, the team-based care.

However, to date, there has been little agreement on how to design clinic layouts to support the teamwork experiences of staff members and patients. For instance, Kaiser Permanente's "Next-Gen Medical Offices" focuses on patient experience and opens up team areas to patients (Bluestein, 2016, March 22), and in contrast, the Veterans Affairs adopts a totally different type of clinic module called "on- and off-stage module," which visually disconnects staff team areas and patients (U.S. Department of Veterans Affairs, 2016). While most team-based clinic layouts provide shared team spaces for collocation of

staff members, they vary significantly in terms of the visual interfaces— visual relationships between two categories of users formed by layouts regulating opportunities and ways they meet and interact—between staff members and patients, especially visual exposure levels to patients.

Previous studies, mostly in workspace settings, have reported the positive impact of the visual connections between inhabitants (employees) on teamwork and communication (Heerwagen et al., 2004; Markhede & Koch, 2007; Rashid et al., 2006). Opening up staff team area and increasing visual connections between staff members and patients also seems to have a positive impact on patients, although no empirical study has been conducted yet. In clinics where team areas are visually opened to patients, patients can see staff members working, may feel the transparency of the teamwork, and may eventually consider themselves as part of the team. This study looks at both staff members and patients of the same clinics and investigates how arrangements may differentially affect staff and patient perceptions.

Among many clinics who adopt a team-based approach in their clinic design, this study empirically investigates four team-based primary care clinics. The four clinic were chosen since a) they are associated with healthcare organizations advocating for team-based approach, b) the layouts show a varying range of team-layout modules reflecting the current debate in the field, and c) and their floorplans and access to clinics including staff members and patients were available. This study attempts to answer the following questions: would providing visual connections between staff members help them perceive themselves as a team and recognize the emphasis on teamwork?; and, would allowing

patients see staff team area support the clinic to convey a collaborative image to patients where patients can feel as part of the team?

4.2 Theoretical Foundation and Literature Review

4.2.1 Representational Function of Space

Architectural and spatial design has representational and symbolic functions, expressing organizational culture and values (Baldry, 1997; Berg & Kreiner, 1990; Davis, 1984; Duffy, 1974a, 1974b; Edelman, 1978; Elsbach & Bechky, 2007; Hatch, 1990; McElroy & Morrow, 2010; Peponis et al., 2007; Steele, 1973; Vilnai-Yavetz, Rafaeli, & Yaacov, 2005; Zalesny & Farace, 1987).

Buildings convey organizational values or professional image to both inhabitants and visitors (Baldry, 1997; Bitner, 1992; Kotler, 1974; Parish et al., 2008). It is important to consider both employees and consumers (customer, clients, or patients) at the same time for the impact of physical environments on individual experience, while there is a lack of understanding of visitors' viewpoint (Bitner, 1992). The following paragraphs describe diverse perspectives of the representational function of space.

First, space reflects the status of individuals. For instance, furniture arrangements (e.g., locations of judges, juries, press, defendants, and prosecutors; the height of the chars in which they are seated, etc.) in court rooms reflect the status of specific roles and the values of judicial systems (Hazard, 1962), and reflect the hierarchical relationships between people (Gutman, 1972). In workspaces, physical settings were found to symbolize the status of individuals, which were found to be associated with the psychological

outcome of the employees. For instance, employees with private offices reported higher satisfaction (Hatch, 1990), employees with ergonomic office furnishing and better indoor environment showed higher job satisfaction and perceived performance (Kim & Jung, 2015), and nurses in a newly constructed part of a building showed higher job satisfaction and lower job stress (Parish et al., 2008). Furthermore, the change of office design from traditional office layout to open-plan layout has been associated with differential effects across positions for perceived levels of work area adequacy, privacy, and satisfaction (Zalesny & Farace, 1987).

Physical properties also reflect the organizational culture and convey its meaning to employees. For instance, the New York Times' new headquarters was designed with stairways connecting the floors with best views in order to express organization's dedication to the connection of departments (Thurm, 2005). Also, the change of office design to the new, modern and open-plan arrangement was associated with employee's perception of organizational culture as less formal and more innovative (McElroy & Morrow, 2010).

Physical environments also convey organization's values and their images to visitors (Baldry, 1997; Bitner, 1992; Kotler, 1974; Parish et al., 2008). Customers not only experience the service the organization provides, but also experience the physical setting of the organization (Bitner, 1992). The physical environment becomes a discriminative stimulus for professional images (Kotler, 1974), and conveys the professional image and purpose of the organization to customers (Bitner, 1992). For instance, Klingbeil (2004) found that seeing a neat office made prospective employees stay in the office. Bitner (1990)

reported that the appearance of the physical environment (organized vs. disorganized) was associated with customer perception of the service quality.

While these studies illustrate the representational function of physical properties on the perception of inhabitants and visitors, its relationships are not yet fully studied (Berg & Kreiner, 1990; Duffy, 1974a; Kim & Jung, 2015). Moreover, there is still a lack of understanding of visitors' perspective Bitner (1992).

4.2.2 Team-based Primary Care Clinics

The importance of teamwork in primary clinics have been long recognized (Delva et al., 2008; Jesmin et al., 2012; Samuelson et al., 2012; Shoemaker et al., 2016). Many healthcare organizations are emphasizing team-based care in their care models (Kennedy & Nordrum, 2015; Schottenfeld et al., 2016; U.S. Department of Veterans Affairs, n.d.), and more than 12,000 practices are providing team-based care with Patient-Centered Medical Home recognition (National Committee for Quality Assurance, n.d.).

There is a growing body of literature on the benefits of teamwork in healthcare settings. A number of researchers have found that improved teamwork of staff members is associated with better patient outcomes (Goldberg et al., 2013; Hogg et al., 2009; Jesmin et al., 2012; Kanter et al., 2010; McLean et al., 2008; Pape et al., 2011; Rosser et al., 2011) as well as improved quality of care and patient satisfaction (Goldberg et al., 2013; Hogg et al., 2009; Kanter et al., 2010; Rosser et al., 2011).

For measuring teamwork in healthcare settings, there is an extensive list of instruments, strategies, and programs (Agency for Healthcare Research and Quality, n.d.;

Shoemaker et al., 2016; Valentine, Nembhard, & Edmondson, 2015). Among various teamwork measurements, this study uses survey instruments assessing the perception of teamwork, since survey instruments were found to be reliable measurements of teamwork (O'Leary et al., 2012). For instance, higher perception of teamwork and collaboration in survey results were found to be associated with better patient outcomes (Narasimhan, Eisen, Mahoney, Acerra, & Rosen, 2006; O'Leary et al., 2009; Pronovost et al., 2003).

While patients are a critical entity of the team-based approach (Schottenfeld et al., 2016), far too little attention has been paid to "patient's perspective" regarding staff teamwork (B. Henry et al., 2013; Shoemaker et al., 2016). Patients' perception of staff teamwork is meaningful since it is associated with the patients' perception of safety (B. Henry et al., 2013; Rathert et al., 2012), and overall satisfaction (B. W. Henry et al., 2014). Only one survey instrument measuring patients' perception of staff teamwork was identified in an extensive review of teamwork measurements (Shoemaker et al., 2016).

4.2.3 Impact of Built Environments on Teamwork

There is a limited number of studies exploring the impact of space on teamwork or collaboration. Most studies exploring the relationships between spatial properties and teamwork focus on process variables, such as communication, rather than teamwork as an outcome construct. This may be partly caused by the difficulty of measuring teamwork (O'Leary et al., 2012). Moreover, there is a limited number of studies looking at design variables and teamwork in healthcare settings (Gharaveis, Hamilton, & Pati, 2017).

While a few studies examined interesting teamwork variables (e.g., co-author frequency or considering other members as a core team members), the spatial metrics for

these studies are limited: co-location or categorical differentiation of proximity between offices (Kraut et al., 1988; Patterson et al., 2015). Kraut et al. (1988) found that researchers on the same corridor or the same floor of the building reported more frequent communication and collaboration. Patterson et al. (2015) found that team members collocated in the same physical space considered each other as a core team member.

Ying and her colleagues reported a couple of related studies as well. The authors found that distances between workstations and meeting areas or amenity spaces were strongly associated with level of perceived support for collaboration (Ying Hua, Loftness, Heerwagen, & Powell, 2011; Ying Hua, Loftness, Kraut, & Powell, 2010). However, the studies were not about the perception of the teamwork, but rather about the perception of the support for collaboration (Ying Hua et al., 2011; Ying Hua et al., 2010). Ying Hua et al. (2012) conducted another study in a healthcare setting, looking at centralized or decentralized nurse stations. They did not find any significant differences in Nursing Team Collaboration Survey results between distinct spatial layouts.

Most studies in healthcare settings explore the impact of nurse station decentralization and centralization on teamwork. Pati, Harvey, Redden, Summers, and Pati (2015) found that self-reported level of staff collaboration decreased in a decentralized nursing layout. Corresponding to this study, Real, Bardach, and Bardach (2017) reported that nurses in decentralized nurse stations reduced nurse interactions and teamwork in their qualitative measurements. Lastly, a recent exploratory study in emergency departments identified visibility as an important factor affecting teamwork and collaboration (Gharaveis, Hamilton, Pati, et al., 2017).

4.2.4 Research Questions: Visibility and Teamwork Perception

Visual connections between staff members were found to have positive impact on staff teamwork and communication by bringing attention to the existence of other staff members, encouraging them to approach each other (Gharaveis, Hamilton, Pati, et al., 2017; Heerwagen et al., 2004; Markhede & Koch, 2007; Rashid et al., 2006). Similarly, this study expects that visual connections between staff members within the shared team area emphasizes the importance of teamwork in team-based primary clinics, and therefore will improve teamwork perception of staff members. Furthermore, similar to Bitner (1990)'s study regarding the customer service satisfaction study, it is also expected that visual connections between staff members and patients during their visits will allow patients to perceive the value of teamwork in the clinics.

The main research question of this study is how visual exposure levels of team members determined by overall layout convey organizational value of teamwork to both staff members and patients. This study investigates the impact of the same visual content (seeing staff workstations) on two different entities (patients and staff members). This study postulates that the visual access of staff members, represented with staff workstations, would have similar positive effects on staff members' and patients' teamwork perception. Two hypotheses in relation to the research question are:

> *Hypothesis 1: Clinics, where staff members can see more of other staff members' workstations, will have higher perceptions of teamwork.*
>
> *Hypothesis 2: Clinics, where patients can see more of other staff members' workstations, will have higher perceptions of staff teamwork.*

4.3 Methods

4.3.1 Settings

This research studied four team-based primary clinics: two clinics from Mayo Clinic and two clinics from Emory Clinic. The four clinics have shared physical team spaces where care team members, including providers, work together. The clinical layouts vary, especially in location and the openness of the said team spaces, showing a range of different visual exposure levels. Emory Clinic A's open team space is centrally located, within close distance of other exam rooms. Thus, space is visually exposed to patients. On the other hand, Mayo Clinic D's team room is separated from patients' visibility and accessibility. Emory Clinic A, Emory Clinic B, and Mayo Clinic C all have opened and enclosed team areas in the clinic, while Mayo Clinic D has relatively enclosed team area in their clinic (Table 12). This various clinic layout type generates different interfaces between staff members and patients, which this study focuses on. There are multiple differences between the four clinics beyond the clinic layouts that are not controlled, including their organizations, culture, technology, and others. This study was an opportunity to investigate the four clinics acknowledging the differences between them beyond the built environments.

Figure 25 – The layout of the four clinics. Grey areas represent team spaces, and blue areas indicate exam rooms.

Table 12 – Summary descriptions of the four team-based primary care clinics.

	Clinic A	Clinic B	Clinic C	Clinic D
Overall description				
Organization	Emory Clinic	Emory Clinic	Mayo Clinic	Mayo Clinic
Service line	Primary Care	Primary Care	Primary Care	Primary Care
Geographic location	Atlanta, GA	Atlanta, GA	Arcadia, WI	Rochester, MN
Architectural description				
Designed by	A local design firm in Atlanta, GA	A local design firm in Atlanta, GA	A national design firm with local offices	A national design firm with local offices
Year built/renovated	2011	2012	2016	2016
Layout type (Team room)	Open + Closed	Open + Closed	Open + Closed	Closed
Clinic area (centerline, sqft)	2,859	12,179	12,251	21,684
Number of exam rooms	6	28 (14+14)	13	30 (15 + 15)
Operational description				
ERM adopted before the construction	Yes	Yes	Yes	Yes
Size of enrolled patient population	11,400	4,000	4,000	15,000
Number of staff members (Admin not included)	15 totals (4 Providers; 2 RNs; 2 LPNs; 3 MAs; 1 Psychologist; 1 PSC; 1 Nutritionist)	34 totals: 9 Providers, 2 RNs, 7 LPNs; 8 MAs; 1 SW; 6 PSCs; 1 RC)	27 totals (6 Providers; 6 RNs; 5 LPNs; 2 BH; 2 Interpreters; 6 Receptionists)	60 totals (19 Providers; 10 RNs; 13 LPNs; 3 Care Coordinators; 1 SW; 1 Pharm; 1 BH; 3 Patient Appt Coordinators; 9 Clinical Assistants)
Number of teams	1 Team	2 Teams	1 Team	2 Teams
Exam room assignment	Shared by providers	Assigned per provider daily	Per provider	Shared by providers

4.3.2 Visual interfaces: staff-staff and patient-staff relationships

This paper focuses on the visual exposure of staff members' workstations to (1) other staff members (staff-staff) and (2) patients (patient-staff). For the two variables, the content of visibility is the same as the staff workstation, but the agents of the visibility is different: the staff members and patients. The first variable (staff-staff visual interface) quantifies how many other staff workstations each staff member can see from their workstations, and the second variable (patient-staff visual relationship) analyzes how many staff workstations patients can see on their way to their exam rooms. These two visual attributes have been analyzed using the VisualPower tool (Lim et al., 2018). Each staff workstation was represented with a point. Patient's paths were drawn from the waiting room to all exam rooms with the shortest distance. Then, the paths were represented with a set of points with 1 ft. interval.

4.3.3 Outcome Measurements

The study qualitatively observed staff members and measured subjective teamwork perception of both staff members and patients using paper survey during the data collection visits to clinics. A copy of staff and patient surveys are included in the Appendix B and C.

4.3.3.1 Qualitative observations

Each clinic was observed for 2-3 days during weekdays. Most observations were conducted in team areas and overall clinic areas, focusing on staff interactions and staff-patient interactions. Activities occurring inside exam rooms were not observed.

4.3.3.2 Staff teamwork survey

All staff members who worked in clinics during the data collection visits were asked to participate in the survey, which included 4 questions about the perception of teamwork (Agency for Healthcare Research and Quality, 2017). A total of 88 staff members from four clinics answered the teamwork items on the survey. Invalid responses such as unanswered questionnaires, or participants who were not staff members of the clinic were excluded, and as a result, a total of 83 responses were analyzed. The teamwork items showed high construct validity according to the Cronbach's alpha test (4 items; α = .843).

4.3.3.3 Patient teamwork survey

Patients' perception of teamwork was measured during and after the data collection visits to clinics. The first survey had a total of 16 items, 10 items from the Patients' Insights and Views Observing Teams (PIVOT) (B. Henry et al., 2013), and 6 newly written items. Patients were asked to answer whether they agree or disagree on multiple statements regarding staff teamwork (e.g., I liked the way the team worked together, I knew who was in charge, etc.) in 5-point Likert scale. After surveying patients at two Emory clinics, 2 newly written items were deleted and the survey was modified to have a total of 14 items. As a result, a total of 235 responses were collected. After excluding invalid responses (e.g., unanswered surveys, unreliable responses, etc.), a total of 205 patient responses were included in the analysis. The responses from Mayo Clinic C were low due to the clinic's lower volume of patient visits. The survey showed high internal consistency according to the Cronbach's alpha test (14 items; α = .908).

4.3.4 Statistical Analysis

In order to explore the relationships between visual interfaces and teamwork perceptions, multiple steps were followed. First, the tendency between visual interfaces and teamwork perception were plotted together using Microsoft Excel. Then, the levels of teamwork perception were compared between clinics by comparing the means of perception levels using a nonparametric Kruskal-Wallis H Test, and the relationships were analyzed using correlation analysis using SPSS 22 (IBM, n.d.).

4.4 Results

4.4.1 Summary Results of Independent and Dependent Variables

4.4.1.1 Visual Interfaces

Two visual interfaces between staff-staff and staff-patient were analyzed using the VisualPower tool (Lim et al., 2018). The results of the two visibility variables in each clinic are illustrated in Table 13 and subsequent figures. Figure 27 and Figure 28 illustrate levels of visibility at each location using grey color scheme indicating darker colors with higher values. The table aggregates all agent-point locations and describes the mean and the ratio values for each clinic. As shown in Figure 26, clinics show various visual interface patterns. Mayo Clinic D has the highest value for the staff members' visibility, while patients can rarely see staff workstations on their paths to exam rooms. Mayo Clinic C and Emory Clinic A have relatively high values for both staff-staff and patient-staff visual connections. On the other hand, Emory Clinic B has low values for both visual interfaces.

Table 13 – Results of visual interfaces analyses.

Variables	Clinic A	Clinic B	Clinic C	Clinic D
1. Staff members seeing other staff workstations				
Number of workstations	14	33	21	53
Average number of visible other workstations	4.4	7.0	5.7	27.5
Total number of visible workstations	13	32	20	52
Ratio	34.1%	22.0%	28.6%	53.0%
2. Patients seeing staff workstations				
Number of patient path points	95	426	198	353
Average number of visible staff workstations	4.83	2.54	7.56	0.36
Total number of visible staff workstations	14	33	21	53
Ratio	34.5%	7.7%	36.0%	0.7%

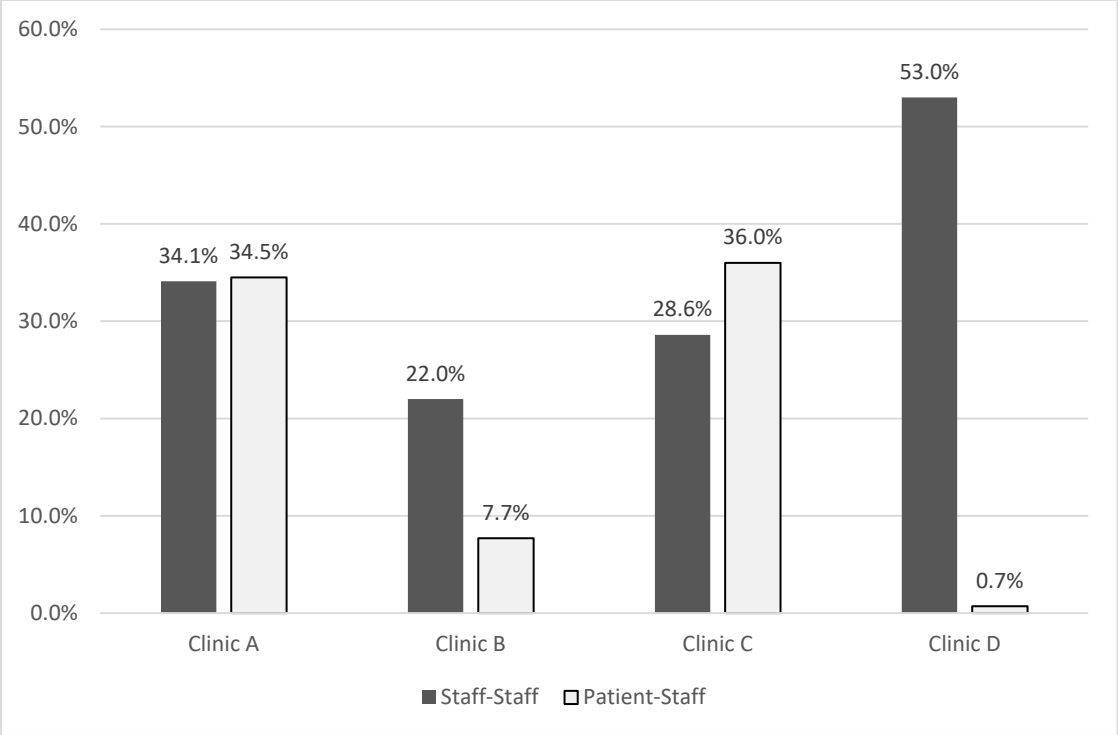


Figure 26 – Visual interfaces of four clinics. The four clinics show distinct levels of staff-staff and patient-staff visual relationships.

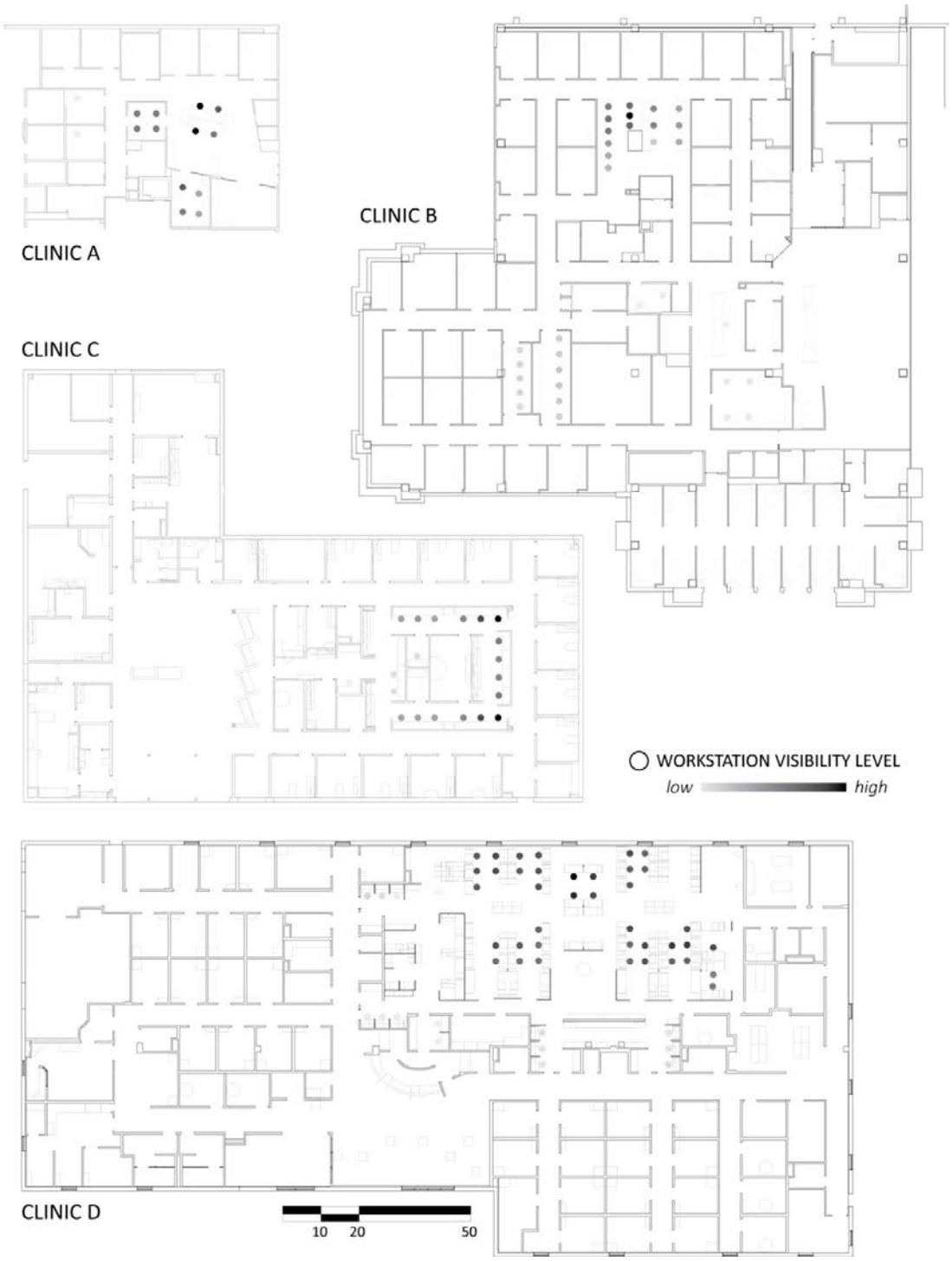


Figure 27 – Staff members seeing other staff members' workstations. Staff members in all four clinics are visually connected to each other with varying degrees. Clinic B shows the lowest level of connection (22% on average), and Clinic D shows the highest visual connections between staff workstations (on average, 53%).

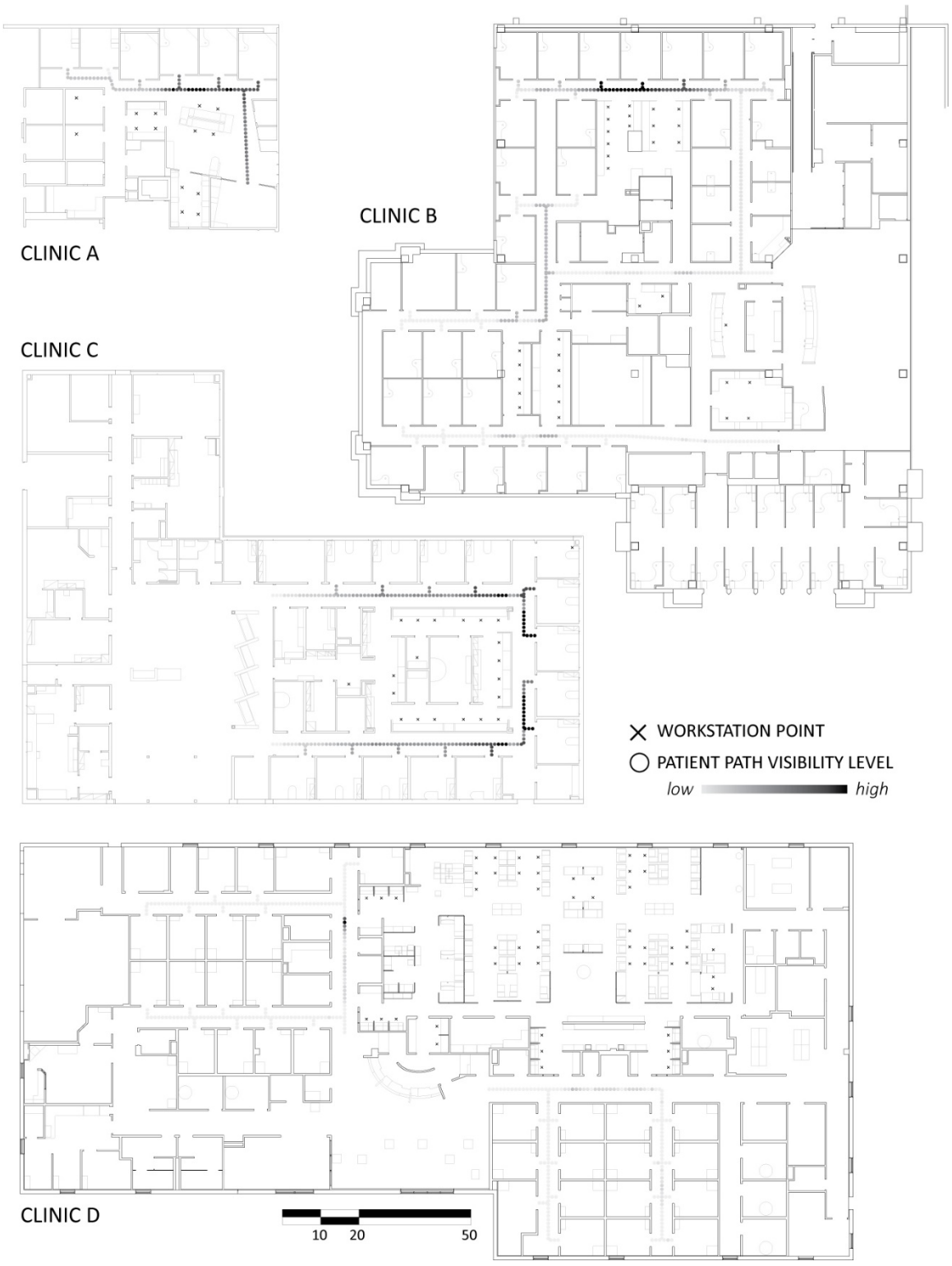


Figure 28 – Patients seeing staff members' workstations. Patients in Clinic A and Clinic C can see more of staff workstations compared to Clinic B and Clinic D. Patients in Clinic D can rarely see staff workstations in the team area.

4.4.1.2 Teamwork Perception

Both staff members and patients of the four clinics answered teamwork perception questionnaires. As shown in Table 14 and Figure 29, teamwork perception scores of all four clinics show relatively high values (higher than 4 in the scale of 5) for both staff and patient perspectives. Among the four clinics, the differences between the highest and the lowest scores are 0.80 for staff perception and 0.28 for patient perception. Mayo Clinic D scored the highest for both staff and patient teamwork perception scores. Emory Clinic B scored the lowest for the staff perception score, and Mayo Clinic C reported the lowest score for the patient teamwork perception.

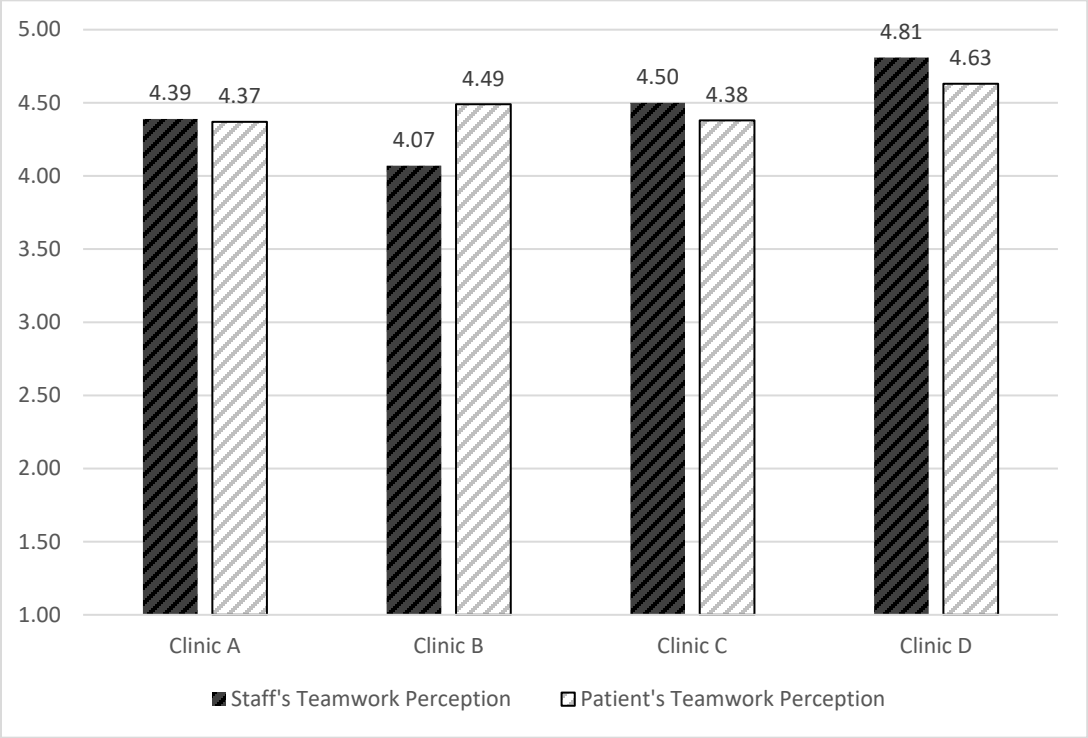


Figure 29 – Teamwork perception scores of four clinics. The four clinics show relatively high perception of staff and patient teamwork. Staff teamwork perception varies a little, and patient teamwork perception is similar among the four clinics.

Table 14 – Descriptive statistics of teamwork perception surveys.

	Staff Teamwork Perception (4 items; α = .843)			Patient Teamwork Perception (14 items; α = .908)		
Clinic	N	Mean	SD	N	Mean	SD
Clinic A	14	4.39	0.50	58	4.37	0.47
Clinic B	15	4.07	0.71	63	4.49	0.60
Clinic C	19	4.50	0.42	24	4.38	0.51
Clinic D	35	4.81	0.31	60	4.63	0.40
Total	83	4.54	0.53	205	4.48	0.51

4.4.2 Differential Effects of Visual Interfaces on Staff and Patient Teamwork Perception

While the effect of visual access to staff workstations was expected to have similar positive impacts on staff and patient teamwork perceptions, the results reported two different patterns of relationships.

4.4.2.1 Higher visual connections between staff members support staff teamwork perception

As shown in Figure 30, the staff-staff visual interface and staff teamwork perception shows a fairly positive linear relationship. Mayo Clinic D especially showed the highest percentage of staff-staff visibility value and scored the highest for the staff teamwork perception. Emory Clinic B with the lowest visibility score reported the lowest staff teamwork score.

Since the data is not normally distributed, the nonparametric Kruskal-Wallis H Test was conducted to statistically compare the teamwork perception mean scores. The test showed that there were statistically significant differences in teamwork perception scores

between the four clinics, $\chi^2(3) = 23.094$, $p < .001$, with a mean rank teamwork score of 33.43 for Clinic A, 23.47 for Clinic B, 38.61 for Clinic C and 55.21 for Clinic D. Multiple pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction. This post-hoc analysis reported that staff teamwork perception score of Clinic D (mean rank = 55.21) is significantly higher than that of Clinic A (mean rank = 33.43) (p=.018) and Clinic B (mean rank = 23.47) (p<.001). The Eta Squared was reported to be η^2=.254, indicating that the differences between clinics explain 25% of the total variance. Furthermore, the positive linear relationship between the levels of staff-staff visual interface and staff teamwork perception were found to be statistically significant according to Pearson correlation analysis, r=.914, p=.043 (1-tailed). In summary, staff members in clinics where they can see more of other staff workstations were found to have higher perception of teamwork, supporting hypothesis 1.

Figure 30 – Staff-Staff visual interface and staff teamwork perception. Clinics with higher visual connections between staff members have higher staff teamwork perceptions.

4.4.2.2 Higher visual exposure levels are associated with lower patients' teamwork perception

Exploration of the relationship between patient-staff interface and patient teamwork perception yielded an interesting result. Contrary to expectation, clinics exposed to patients reported slightly lower patient teamwork perception (Clinic A and Clinic C), and clinics less exposed to patients showed higher patient teamwork perception (Clinic D and Clinic B) (Figure 31). The differences between the levels of patient teamwork perception were confirmed to be statistically significant with Kruskal-Wallis H Test result ($\chi^2(3) = 10.277$, $p = .016$), with a mean rank teamwork score of 86.29 for Clinic A, 108.26 for Clinic B, 91.08 for Clinic C and 118.39 for Clinic D. Specifically, differences between Clinic D and Clinic A was confirmed in post-hoc pairwise comparison analysis (adjusted p=.018). However, the effect size was found to be small according to the Eta squared value (η_p^2=.036). The negative linear relationship was statistically supported with Pearson Correlation analysis (r = -.942, p=.029, 1-tailed).

Hypothesis 2, which postulated that patients would show a similar pattern to staff members in their teamwork perception in relation to visual access to staff workstations, was not supported. Patients in clinics where they can see more of staff workstations showed (slightly) lower perception of teamwork. Showing staff work area to patients may not necessarily increase patients' perception of teamwork. It may decrease patients' perception of teamwork with a small effect.

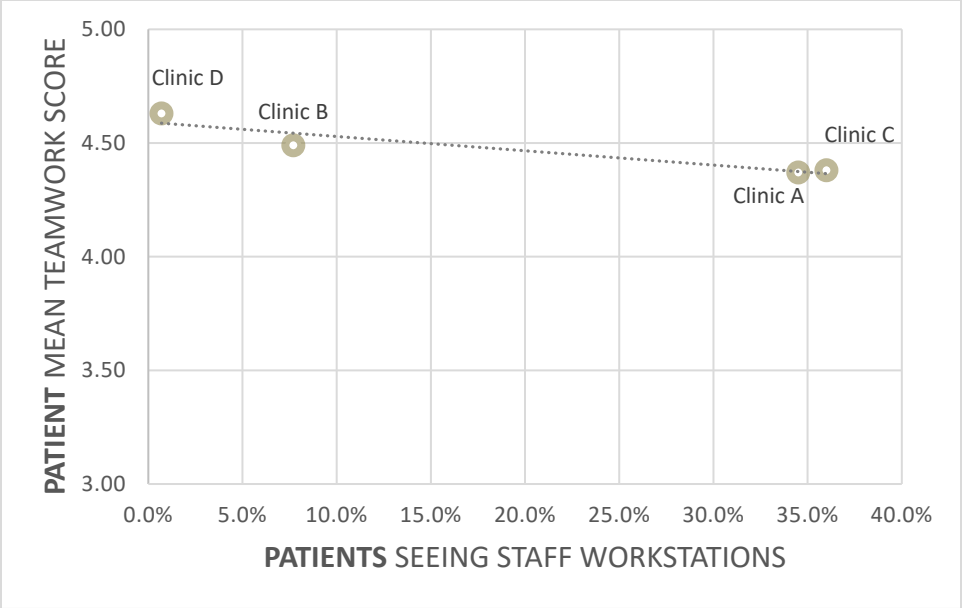


Figure 31 – Patient-Staff visual interface and patient teamwork perception. Clinics with higher visual connections between staff members and patients have lower patient teamwork perceptions.

There are several possible explanations for the unexpected relationship between patient-staff visual interface and patients' teamwork perception. First, it is possible what patients saw was physically sub-divided team rooms in clinics rather than visually connected staff workstations. For instance, Clinic A and Clinic C, which reported lower patient teamwork perception levels, have team areas that are divided into multiple sub-areas. Clinic A has three (or more) workspaces shared by certain roles: a shared provider office, a shared nurse workstation, and a work area for RNs and LPNs. Clinic C has one team area divided by a huddle room in the middle. Patients may have perceived these team rooms as if they are separated offices or areas rather than a larger staff team space providing visual connections between staff members.

Another contributing factor may be the fact that patients do not know the individual staff members' roles and tasks for teamwork. During the interview, a staff member in

Clinic A stated that patients (who are waiting to be taken care of) complain sometimes about staff members not helping them while working at their workstations. Patients waiting for staff members with specific roles (such as front desk person or a rooming nurse) may view staff members with other roles (such as RNs or providers) working at their workstations and believe that some of the members are not working as a team to take care of the patients. While the teamwork of providing care to patients occur in various dynamics including individual heads-down work and interactions between staff members, patients' lens of teamwork may be centered on their interaction with staff members.

Another possible explanation is that the visual exposure of staff workstations is not sufficient enough to convey the value of teamwork to the patients. What patients actually see during their visits depend on individual circumstances, which may have a stronger effect on the patients' perception of staff teamwork than visual access of staff workstations. As Bitner (1990) reported, even the appearance of staff workstations (whether they are organized or disorganized) influenced customers' service quality perception. Likewise, in team-based clinics, seeing interactions or conflicts of team members in team area would have a stronger impact on patients' perception than seeing empty or perhaps disorganized team workstations. As Goffman (1959) described in an example of the mental hospital setting (e.g., permit outsiders to see only special visiting rooms with nice furnishings, and well-dressed, well-behaved patients), controlling what patients can and will see in team-based clinics may be needed in order to convey the collaborative image to the patients.

It is also possible that patients' teamwork perception is related to their satisfaction. Many studies reported that teamwork related constructs such as teamwork culture (Meterko, David, & Young, 2004), staff responsiveness and communication (Andaleeb,

2001), and provider and patient communication quality (Lin, Lin, & Lin, 2010; Moret, Rochedreux, Chevalier, Lombrail, & Gasquet, 2008) are significantly associated with patient satisfaction. While good teamwork can improve patient satisfaction, it is also feasible that low patient satisfaction can decrease patient perception on staff teamwork. Discontent patients may generally give lower ratings for staff teamwork. This is an unsupported assumption since patient satisfaction levels of the clinics were not investigated in this study.

A potential alternate explanation is that other process factors, such as whether information is quickly and accurately transmitted, have stronger impacts on the patients' teamwork perception. According to Berry, Wall, and Carbone (2006), there are three types of clues that significantly and specifically influence customers' service experience: functional clues (technical quality of service), mechanic clues (sensory presentation of service), and humanic clues (appearance and behavior of service providers). The clinic and team room designs are parts of mechanic clues where patients can visually experience the service. There are other significant influential factors that form patients' perception of teamwork, such as the quality of patient care (functional clues) and the behavior of staff members (humanic clues), which were not controlled in this study. These factors were not controlled in this study and may have had stronger effects than the mechanic clues.

4.4.3 Visual Interfaces and Patient Experiences

4.4.3.1 Openness of team area enables positive patient-staff member encounters

While this study found a significant negative relation between visual exposure of team area and patient teamwork perception, openness of staff work area to patients may

support patients in having a better encounter/experience with more staff members. There were multiple observed instances where positive interactions between patients and staff members occurred in relation to visual interfaces.

Figure 32 illustrates interactions between patients and staff members in Clinic A. As shown in the figure, multiple interactions between patients and staff members occurred around the visually exposed nurse workstation area. When patients arrive and leave the clinic, they were greeted or escorted by multiple staff members, not by an individual staff member. Not only a front desk person but also rooming nurses at the visually exposed nurse workstation area (Medical Assistant in Clinic A) greeted when patients arrived. Many rooming nurses and other staff members also reacted to leaving patients. In Clinic A, which has high staff-staff visual connections and patient-visual connections, staff members seemed to be able to collaboratively support patients. For instance, when a patient came out from the exam room after seeing a provider, the patient asked a question to a rooming nurse who was sitting at the visually exposed nurse station in order to verify a provider's note (e.g., "I need to know the name of physical therapists that the doctor recommended"). When the rooming nurse could not answer the question, a group of staff members, including an LPN in another work area, quickly came to collaboratively answer the question for the patient in the nurse workstation area. This collaborative support for the patient was possible to occur because the patient could see the rooming nurse in the team area (patient-staff visual interface), and because the other staff members could also see and understand the interaction between the patient and the rooming nurse (staff-staff visual interface).

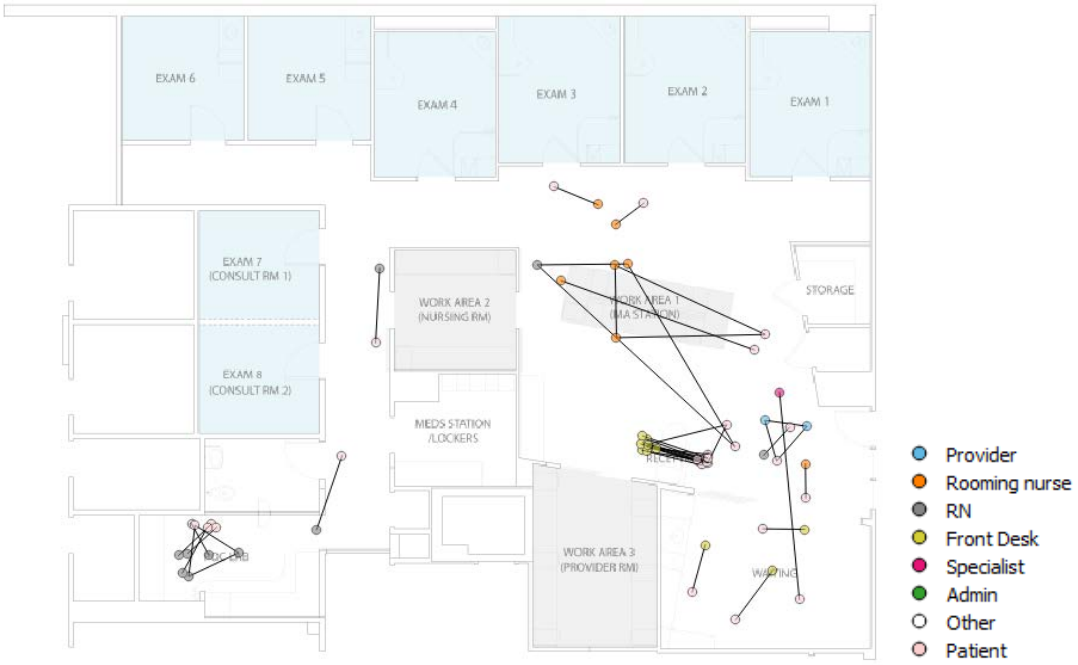


Figure 32 – Communication location between patients and staff members. Positive interactions between staff members and patients were observed at visually exposed team areas in Emory Clinic A.

4.5 Discussion

This study investigated and compared the effect of visual access to staff workstations and found differential effects of staff-staff and patient-staff visual interfaces on teamwork perception. While the relationships between visual interfaces and staff/patient's teamwork perception showed clear linear tendencies, surprisingly, staff-staff visual interface and patient-staff visual interface showed opposite directions of correlations on teamwork perception. Staff members reported higher teamwork perception in clinics where more staff workstations are visually connected (hypothesis 1 supported), and patients reported higher teamwork perception in clinics where staff workstations are less visually exposed to patients (hypothesis 2 contradicted). However, while the openness of

team areas was associated with lower teamwork perception of patients, the openness enabled positive interactions between staff members and patients.

This study has shown that what organizations show to inhabitants and visitors in their facility affects their perceptions. Organizations can emphasize organizations' value or culture via clinic layout design. For instance, this study found that providing layout that can support visual connections between staff members can increase their perception of teamwork. Clinic layout design also impacts the visitors' opinions of the organization. However, the results of the study highlight that a more careful consideration is needed to select and present the desired images to the patients. As Berry et al. (2006) stated, often small clues affect customers and patients' perception of their experiences. Even showing an appearance of an office (e.g., neat or disorganized) has an impact on the visitors' perception of the organization (Bitner, 1990; Klingbeil, 2004). In order to convey professional images to visitors, what visitors can see should be controlled instead of opening everything for their view, as Goffman (1959) noted. For instance, in order to convey a collaborative image of the clinic, it may be better to design the clinic layout in a way that visitors can perceive and know the existence of shared and visually connected team spaces rather than showing all staff work areas. When visitors can see all employee workstations, visitors' perception of teamwork may vary depending on individual circumstances (e.g., whether employee interactions occur, offices are disorganized, etc.). Providing the spatial layout where visitors can perceive and see the organizational value and have positive interactions with employees is critical for their experience. Beyond designing the clinic layout and team rooms, consciously orchestrating all influential factors

including physical spaces, quality of services and behaviors of staff members is critical to convey professional and collaborative images to the patients (Berry et al., 2006).

From the staff perspective, this means it is important to provide less exposed backstage areas to staff members. While not all clinic areas need to be back-staged from patients (which may actually hinder some positive staff and patient interactions observed in Clinic A), allowing staff members to have interactions away from patients somewhere in the clinic, and thus not showing everything to patients, would bring value to both staff members and patients as found in this chapter and Chapter 3. Finding the balance between opening up team areas to both patients and staff members for better interactions, and veiling staff work area for private interactions between staff members and for controlling patients' spatial experience would be challenging but necessary for both patients and staff members in team-based primary clinics.

Several limitations to this study need to be acknowledged. First, it has a limited sample size. Only four clinics were empirically studied, and as a result, some analyses were not feasible (e.g., further statistical analysis). While this study found some interesting results, generalizability of the finding needs to be further investigated. There are also various other factors that might impact the perception of teamwork in the clinics such as organizational culture, care proves, or technology that this study was not able to control. While these factors were observed and noted, they were not statistically controlled or investigated. Lastly, while this study focused on the perception of teamwork from both staff and patient perspectives, there are other outcomes for staff and patient experience in relation to visual interfaces of clinics, as briefly noted in the discussion section. Future studies with a holistic approach of staff and patient experience may provide a

comprehensive picture of the role visual interfaces of the layouts. Furthermore, future studies conducting design explorations attempting to find the balance between the openness and closeness with a larger number of clinic layouts are expected for the translation of the findings in this study into design strategies for team-based primary clinics.

CHAPTER 5. CONCLUSIONS

5.1 Summary of Findings

This section encapsulates the findings of the study across the chapters. It illustrates a descriptive account of what makes good teamwork, what the expected findings were, and what the actual findings were.

5.1.1 Visual Interfaces between Staff Members and Staff Awareness

The first aspect of teamwork that this study investigated was the awareness of staff members: being aware of the presence and/or location and/or activities of other staff members. Unlike many workspace settings where employees mostly sit and work at their workstations, in primary care clinics, staff members walk around the clinic in order to take care of patients. Rooming nurses escort patients from waiting areas to exam rooms. Providers or nurses (depending on the type of patient visits) walk back and forth from their workstations to exam rooms and the waiting area during the patient visits. Therefore, in order for staff members to collaboratively take care of the patients, they first need to know the current locations and tasks of other staff members. Visual interfaces between staff members determined by the layout of the clinic and team rooms were expected to support or hinder the awareness of the staff members. Specifically, the two main expected findings were:

- Clinics with higher visual access to clinic area may have higher staff awareness of other staff members (*not supported*).

- Clinics with higher visual connections between staff members may have higher staff awareness of other staff members (*not supported*).

Unexpectedly, both assumptions were not supported in the reported levels of staff awareness. While the visual interface levels of the clinics were significantly different, the reported awareness levels of the clinics were similar and relatively high in all clinics. While the self-reported levels of awareness were not different across the four clinics, some negative consequences of the lack of staff's ability to see the clinic area and other staff members were observed. Inhibited visibility made staff members spend additional time searching for each other as well as complicating and delaying patient care process.

5.1.2 Visual Interfaces between Staff Members and Staff Communication

Another critical aspect of teamwork is communication between staff members. In primary care clinics, effective patient care process depends on timely and accurate information exchange before, during, and after a patient visit. While many communications between staff members occur electronically, many staff members still prefer brief face-to-face interactions for the patient care. Clinic and team room designs may affect staff members' ability to have frequent and timely communications by regulating opportunities and methods staff members encounter each other. When staff members can often see and encounter other staff members, the exchange of information may be more fluid and on time, and requests for advice may be made when needed. The expected findings in relation to staff communication patterns were:

- Clinics with higher visual connections between staff members may have higher perceptions of frequent and timely communications (*supported*), and more observed communications (*not supported*).
- Staff members may talk more frequently to each other at locations with higher visual connections between staff members (*not supported*).
- Staff members whose workstation-clusters are physically and visually connected may talk more frequently to each other (*supported*).

The empirical studies of the four clinics found that the visual interface between staff workstations was strongly associated with staff communication patterns. Clinics providing more visual connections between staff workstations reported stronger perceptions of frequent and timely communication, but they were not associated with observed communication frequency. Staff members did not talk more often to other staff members at visually accessible clinic areas, but they talked to each other mostly around their workstations. They also talked frequently to other staff members whose workstations were visually and physically connected with their workstations.

5.1.3 Visual Exposure to Patients and Staff Backstage Communication

Among various types of communications, Chapter 3 focused on patient-related communications between staff members in relation to the visual exposure levels to patients. This specific type of communication was studied in order to test one of the main arguments that opening up team areas to patients makes staff members uncomfortable discussing sensitive information with each other, hindering their teamwork. In other words, this study investigated whether staff members can talk about their patients' healthcare information

with other staff members in clinic areas or in team rooms without being concerned about the locations of other patients. The main expected findings of this chapter were:

- Clinics with lower visual exposure to patients may have lower concerns for having patient-related communications (*supported*).
- Staff members will not prefer discussing sensitive healthcare information at visually exposed areas (*supported*).

As expected, staff members in clinics with less visual exposure to patients reported lower concerns for having backstage communication. The four clinics did not show statistically significant linear relationships, but the clinic with the lowest visual exposure level, with its layout using enclosed team room, had the lowest levels of concern. Across the clinics, staff members preferred team areas and not preferred visually exposed spaces for their backstage staff communications. The distinct patterns of preferred and non-preferred locations identified visually exposed team areas as a possible environmental stress factor imposed on staff members.

5.1.4 Visual Interfaces and Overall Teamwork Perception

The last aspect of teamwork that this study explored was the overall teamwork perception of staff members and patients. While teamwork skills, awareness and communication play critical roles on staff teamwork, how staff members and patients perceive teamwork of staff members is also important since the overall perception levels tell whether the value that the organization wants to emphasize is actually embedded and conveyed (or not) to both staff members and patients. The power of this study is that it

investigated both staff members and patients in the same clinics and looked at their teamwork perceptions in relation to the visual interfaces. The two expected findings were:

- Clinics, where staff members can see more of other staff members' workstations, may have higher perceptions of teamwork (*supported*).
- Clinics, where patients can see more of other staff members' workstations, may have higher perceptions of staff teamwork (*not supported*).

While the relationships between visual interfaces and staff/patient's teamwork perception showed clear linear tendencies, surprisingly, staff-staff visual interface and patient-staff visual interface showed opposite patterns. Staff members reported higher teamwork perception in clinics where more staff workstations are visually connected, and patients reported higher teamwork perception in clinics where staff workstations are less visually exposed to patients. While the openness of team areas was associated with lower teamwork perception of patients, the openness enabled positive interactions between staff members and patients.

Table 15 – Summary of findings across chapters. Staff-staff and patient-staff visual interfaces have significant impacts on staff awareness, communication, backstage communication patterns and teamwork perception of both staff and patient.

Visual interface	Visibility variables	Unit of analysis	Teamwork outcome measurements (Ch.)	Summary findings
Staff-staff	Staff seeing clinic area	Clinic, staff	Awareness survey (3-item) and qualitative observations (Ch. 2)	No specific differences between clinics were reported, however, not having visibility of clinic area may make staff members spend more time for finding each other.
	Staff seeing staff workstation	Clinic, staff	Awareness survey (3-item) and qualitative observations (Ch. 2)	No specific differences between clinics were reported, however, not having visibility of staff members may hinder the patient care.
		Clinic, staff	Communication perception survey (1- & 4-item) (Ch. 2)	Clinics with higher visual connections between staff members have higher perceptions of timely and frequent communications.
		Clinic, staff	Observed communication frequency (Ch. 2)	No specific differences between clinics were reported.
		Space per clinic, staff	Observed communication frequency (Ch. 2)	Staff members did not talk more often at locations where they can see more staff workstations.
		Role-role work-station clusters, staff	Observed communication frequency (Ch. 2)	Staff members whose workstation-clusters are physically and visually connected talked more frequently. Visual connection compensated physical distance between workstations, but distance did not compensate visual disconnection.
		Clinic, staff	Staff teamwork perception survey (4-item) (Ch. 4)	Clinics with higher visual connections between staff members have higher overall staff teamwork perception.
Patient-staff	Patients seeing staff workstation	Clinic, patient	Patient teamwork perception survey (14-item) (Ch. 4)	Clinics with lower visual exposure to patients have higher overall teamwork perception from patients' perspective.
	Patients seeing clinic area (visual exposure to patients)	Clinic, staff	Communication privacy concern survey (4-item) (Ch. 3)	A clinic with the lowest visual exposure to patients has the lowest concern for communication privacy.
		Space per clinic, staff	Preferred-location frequency survey (Ch. 3)	Staff members preferred to have backstage communications at team areas where they were visually less exposed to patients compared to corridors.
		Space per clinic, staff	Not preferred-location frequency survey (Ch. 3)	Staff members did not prefer to have backstage communications at visually exposed areas regardless of the programs of spaces.

5.2 Concluding Remarks

The idea of this thesis started when I first visited Emory Clinic A in 2015. When I entered the clinic, I was amazed with the openness of the team area to the patients. As a visitor, I felt welcomed, and I could see the team area where staff members were working together. I thought this layout would provide good patient experiences, especially making the patients' teamwork experiences positive inside the clinic. The openness of the team area allows patients to see staff members working together in team areas. I expected this openness to help patients to feel as if they are a part of their own care team, which is one of the main goal of the team-based primary care clinics.

The general understanding of the field, as well as the opinions of staff members at that clinic, was that while this layout might be supportive for patients and show the "teamness" of the clinic to the patients, it was not favorable for the staff members because of the lack of privacy. It was quite surprising when this study found that not only are staff members concerned about privacy in opened team-clinics, but patients did not assess teamwork better in these clinics. In fact, patients rated teamwork of the staff members in these clinics lower than the clinics with enclosed team areas. There are multiple explanations for this finding as explained in Chapter 4, but the results of this thesis is not favorable to the opened team clinic layouts. Patients may benefit from the opened team clinics while their perceptions regarding staff teamwork might not improve in opened team clinic layouts. Patients may have better encounters with team members, or even shorter stay in the clinic due to the openness of the team area and visual connections between staff members and patients. In the future, I plan to examine the holistic view of patients'

perspective in different layouts to see how the openness of the team areas support patient experience or outcomes.

A considerable literature has been published on the role of visibility on staff communication. As expected, this thesis also reported the positive effect of the visual connections between staff members on communication. This finding has a significant contribution to the field since this study developed the metrics for assessing visual connections using the Visual Power tool (Lim et al., 2018) and provided empirical evidence on the relationships between visual connections and aspects of teamwork. As mentioned, there is only a limited number of studies investigating the relationships between spatial properties and staff communication in healthcare settings. The studies focus on providing shared spaces where staff members can be collocated as their spatial properties. While the collocation itself is important and has a significant impact on staff communication, there are many critical design properties beyond collocation in designing team rooms and clinic layouts, for instance, visual connections and close distance between workstations. This thesis provides preliminary spatial and visual metrics that are related to many design components of clinics.

The analysis of the specific visual metrics is not only a significant contribution the field but also a meaningful step for myself. The analyses of the fine-tuned visual interfaces were enabled thanks to the recent development of the agent-based visibility analysis tool, Visual Power, which I and my colleagues developed. It was a pleasing experience to test and validate the usefulness of the tool with the empirical data. I hope Visual Power to be a helpful tool for many other researchers and designers who want to analyze and assess various layouts.

The specific visual metrics tested in this study are expected to help designers and facility managers to provide a better layout for teamwork of staff members. The metrics have various design implications regarding the design of team areas in relation to clinic area, and also regarding the design of the interior layouts of team areas. However, they still are “metrics” rather than “design strategies.” It is not easy to quickly translate a layout into a specific metric without analyzing the layout using tools such as Visual Power. This is because numerous design components such as overall layout, location of team areas, walls, partitions, and others impact the metrics together simultaneously. I personally believe the importance of research for better design. As a researcher and a designer, I would like to provide design-applicable findings to designers that they can apply even in time- and budget-limited design processes. However, in order to get research results to get embedded in design processes, additional time and efforts are required to translate the results into design applicable strategies. I would like to conduct further investigation of various clinics to provide a simplified version of layout types and design strategies for teamwork supportive clinics to designers.

This thesis empirically studied four primary care clinics. It was a significant amount of work to visit the clinics, collect data on- and off- sites, and analyze all the spatial and outcome data. However, still, and as always, I feel investigating more clinics may have been better for higher statistical power and for a broader range of team-layout design modules. In the near future, I personally plan to continue empirically investigating more clinics for the holistic view of patient experiences and theoretically exploring variations of clinic layouts for translating the empirical findings into design-applicable strategies.

APPENDIX A. IRB APPROVAL

Georgia Tech Research Integrity Assurance

Protocol Number: H17153
Funding Agency: n/a
Review Type: Exempt, Category 2
Title: Impact of clinical layout on teamwork
Number of Subjects: 450

May 5, 2017
Craig Zimring
Architecture
craig.zimring@design.gatech.edu

Dear Dr. Zimring:

The Institutional Review Board (IRB) has carefully considered the referenced protocol. Your approval is effective as of **5/5/2017**. The proposed procedures and affiliated documents are exempt from further review by the Georgia Tech Institutional Review Board.

Minimal risk research qualified for exemption status under 45 CFR 46 101b.2.
Per 45CFR46.117(c) (2) this study qualifies for a waiver of documentation of consent.
Per 45CFR46.116 (d) this study qualifies for a waiver of consent (for observation portion of study only).

Thank you for allowing us the opportunity to review your plans. If any complaints or other evidence of risk should occur, or if there is a significant change in the plans, the IRB must be notified.

If you have any questions concerning this approval or regulations governing human subject activities, please feel free to contact me at 404.894.6944.

Sincerely,

Carolyn Sims, MPA, CIP
Compliance Officer
Office of Research Integrity Assurance
Georgia Institute of Technology

Georgia Tech Research Integrity Assurance

Protocol Number: H17153
Funding Agency: n/a
Review Type: Exempt, Category 2
Title: Impact of clinical layout on teamwork
Number of Subjects: 450

May 31, 2017
Craig M Zimring
Architecture
craig.zimring@design.gatech.edu

Dear Dr. Zimring:

The Institutional Review Board (IRB) has carefully considered **amendment # 1** for protocol **H17153** referenced above. Your approval is effective as of **5/31/2017**. The proposed procedures are exempt from further review by the Georgia Tech Institutional Review Board.

Minimal risk research qualified for exemption status under 45 CFR 46 101b. 2.

Thank you for allowing us the opportunity to review your plans. If any complaints or other evidence of risk should occur, or if there is a significant change in the plans, the IRB must be notified.

If you have any questions concerning this approval or regulations governing human subject activities, please feel free to contact me at 404.894.6944.

Sincerely,

Carolyn Sims, MPA, CIP
Compliance Officer
Office of Research Integrity Assurance
Georgia Institute of Technology

APPENDIX B. STAFF SURVEY

B.1 A Copy of Staff Survey

STAFF QUESTIONNAIRE

Sex ◯ Male ◯ Female ◯ Prefer not to answer

Years of experience in the medical field

◯ 2 years or less ◯ 3 - 5 years ◯ 6 - 10 years ◯ Greater than 10 years

How long have you worked in this clinic?

◯ 1 year or less ◯ 2 - 3 years ◯ 4 - 5 years ◯ Greater than 5 years

Please identify your role in this clinic.

◯ Primary care provider (e.g. physician, nurse practitioner, physician assistant, etc.)
◯ Specialist (e.g. behavioral health specialist, pharmacist, psychiatrist, nutritionists, etc.)
◯ RN
◯ LPN
◯ MA
◯ Front desk
◯ Administrative personnel
◯ Other (Please specify: _____)

Including yourself, how many people work together as a team?

◯ 2 members ◯ 3 - 5 members ◯ 6 - 8 members
◯ 9 - 11 members ◯ More than 11 members

Which roles do the members of your team have? [Select all that apply]

☐ Primary care provider ☐ Nursing personnel ☐ Specialist ☐ Case or care manager
☐ Social worker ☐ Administrative personnel ☐ Other ( )

Do you work in multiple clinics?

◯ Yes, I regularly float ◯ No, I primarily work only in this clinic

What are the modes of communications that you use with your team members? [Select all that apply]

☐ Formal team/clinic meetings ☐ Ad hoc face-to-face communication ☐ Email/online message
☐ Phone ☐ Others ( )

Among the selected modes, what is the most frequent mode of communication with your team members?

◯ Formal team/clinic meetings ◯ Ad hoc face-to-face communication ◯ Email/online message
◯ Phone ◯ Others ( )

How would you communicate with your team members you cannot find?

( )

How much do you agree or disagree with the following statements?

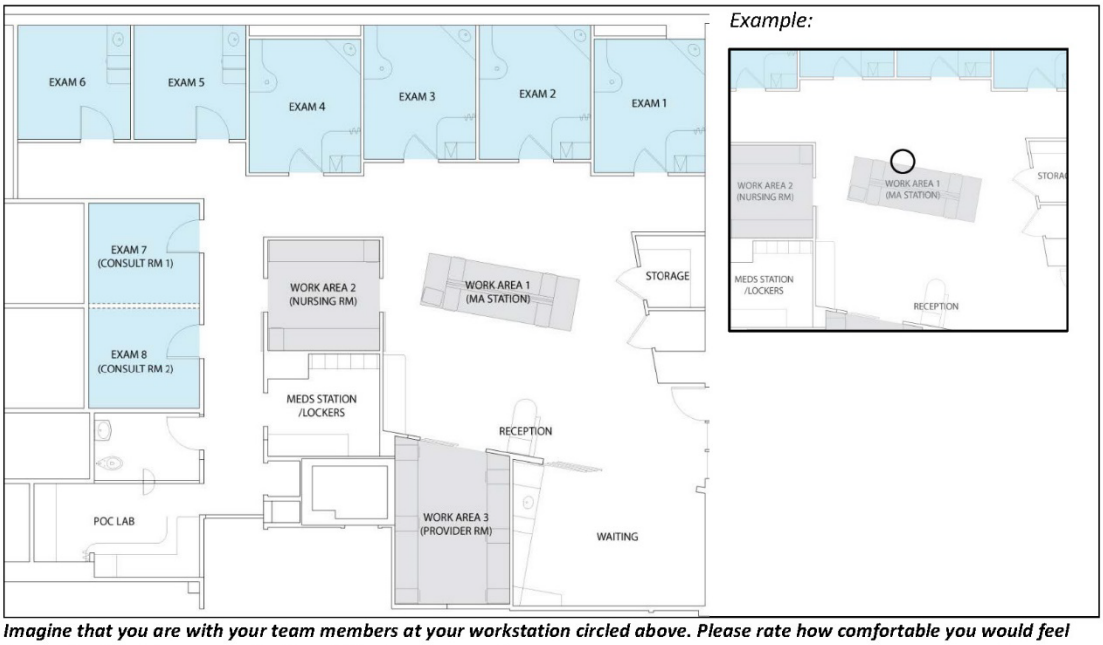
	1 *Strongly* ***Disagree***	**2** *Disagree*	**3** *Neither Agree nor Disagree*	**4** *Agree*	**5** *Strongly* ***Agree***	*Does Not Apply or Don't Know*
1. When someone in this clinic gets really busy, others help out.						
2. In this clinic, there is a good working relationship between staff and providers.						
3. In this clinic, we treat each other with respect.						
4. This clinic emphasizes teamwork in taking care of patients.						
5. There is frequent communication between the team members.						
6. In this clinic, it is easy to find my team members when I need advice/help.						
7. Team members often approach me asking or offering advice/help.						
8. I know when my team members are available and I can approach them without interrupting their work.						
9. In this clinic, it is easy to have awareness of where my team members are and what they are doing.						
10. I get information on the status of patients when I need it.						
11. When a patient's status changes, I get relevant information quickly.						
12. There are needless delays in relaying information regarding patient care.						
13. In matters pertaining to patient care, team communication or briefing occurs in a timely manner.						
14. When I talk with other team members in team areas (primary work areas of team members such as team rooms or team hubs), I am concerned whether other patients might hear private patient information.						
15. I need to adjust my voice when I talk about patients in team areas.						
16. I usually do not talk about patients in team areas, but move into a private space.						
17. When I talk with other team members in team areas about patients, I have to look around to check whether there are other patients who can hear our conversations.						

Below is a floorplan of your clinic. Grey areas indicate team areas and blue areas represent exam rooms. Refer to the floorplan when answering the following questions.

How comfortable are you at interpreting/understanding the floorplan below?

Extremely uncomfortable 1 2 3 4 5 *Extremely comfortable*

Please circle your primary work area on the floorplan. This may be your officially assigned seat or a seat(s) that you usually use during a clinical day.



Imagine that you are with your team members at your workstation circled above. Please rate how comfortable you would feel having the following communications with your team members.

1. *Formal reporting or request for clarification/information/opinion*
   You would like to **share diagnostic information about a patient** (e.g. Lisa is 30 years old and she has diabetes. She met Dr. _____ two weeks ago), or you would like to **get opinions from your team members** regarding a patient (e.g. do you think she is depressed?).

   Extremely uncomfortable 1 2 3 4 5 *Extremely comfortable*

2. *Checking clinic progress*
   You would like to **check clinical progress of patients** with your team members (e.g. which patients are in rooms? have you seen him yet?).

   Extremely uncomfortable 1 2 3 4 5 *Extremely comfortable*

3. *Training students/fellows/new staff members*
   You would like to talk with students/fellows/new staff members and **train them by offering assistance or answering questions**.

   Extremely uncomfortable 1 2 3 4 5 *Extremely comfortable*

4. *Handling interruptions*
   You would like to **get a quick feedback from team members about urgent/emergent patient need** (e.g. she just called me crying. She said she needed someone to talk to).

   Extremely uncomfortable 1 2 3 4 5 *Extremely comfortable*

Assume that you can go any clinical area with your team members to have a communication. Where are your preferred locations for the following communications?

1. *Formal reporting or request for clarification/information/opinion*
   You would like to **share diagnostic information about a patient** (e.g. Lisa is 30 years old and she has diabetes. She met Dr. _____ two weeks ago), or you would like to **get opinions from your team members** regarding a patient (e.g. do you think she is depressed?).
   - □ Please mark ① at location(s) where you would want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

2. *Checking clinic progress*
   You would like to **check clinical progress of patients** with your team members (e.g. which patients are in rooms? have you seen him yet?).
   - □ Please mark ② at location(s) where you would want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

3. *Training students/fellows/new staff members*
   You would like to talk with students/fellows/new staff members and **train them by offering assistance or answering questions**.
   - □ Please mark ③ at location(s) where you would want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

4. *Handling interruptions*
   You would like to **get a quick feedback from team members about urgent/emergent patient need** (e.g. she just called me crying. She said she needed someone to talk to).
   - □ Please mark ④ at location(s) where you would want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

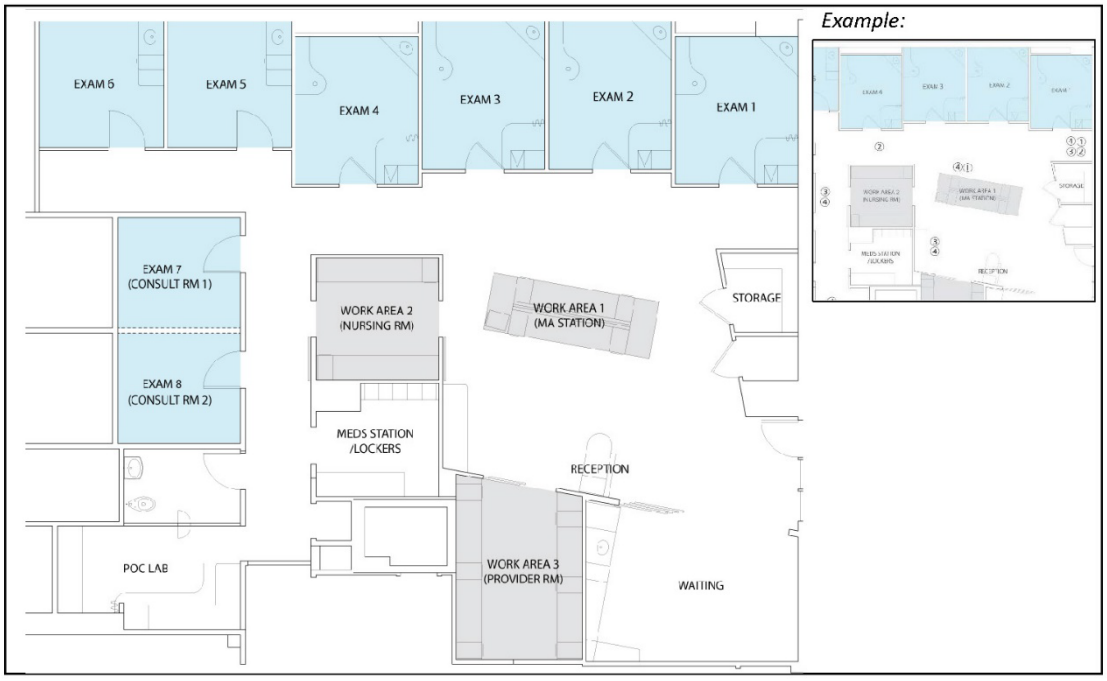
Assume that you can go any clinical area with your team members to have a communication. Where are locations you would NOT want to have the following communications?

1. *Formal reporting or request for clarification/information/opinion*
   You would like to **share diagnostic information about a patient** (e.g. Lisa is 30 years old and she has diabetes. She met Dr. _____ two weeks ago), or you would like to **get opinions from your team members** regarding a patient (e.g. do you think she is depressed?).
   - □ Please mark ① at location(s) where you would NOT want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

2. *Checking clinic progress*
   You would like to **check clinical progress of patients** with your team members (e.g. which patients are in rooms? have you seen him yet?).
   - □ Please mark ② at location(s) where you would NOT want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

3. *Training students/fellows/new staff members*
   You would like to talk with students/fellows/new staff members and **train them by offering assistance or answering questions**.
   - □ Please mark ③ at location(s) where you would NOT want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.

4. *Handling interruptions*
   You would like to **get a quick feedback from team members about urgent/emergent patient need** (e.g. she just called me crying. She said she needed someone to talk to).
   - □ Please mark ④ at location(s) where you would NOT want to have that communication.
   - □ Please check this box if specific location(s) do not matter for the conversation.



If you could make a change on the clinic layout or team area, what would that be?

What would make your team better?

Is there any clinical layout that you prefer over your current clinic? If so, can you describe or draw the layout and explain why you prefer it?

B.2 Staff Survey Teamwork Inventory Test (Factor analysis and Cronbach's alpha)

Rotated Component Matrix[a]

	Component			
	1	2	3	4
Item 1	.381	.486	.321	.362
Item 2	.823			
Item 3	.900			
Item 4	.809			
Item 5	.712	.265	.245	.271
Item 6	.352	.737		
Item 7				.650
Item 8		.838		
Item 9		.780		
Item 10		.382		.706
Item 11		.285		.747
Item 12				.401
Item 13	.323	.401		.403
Item 14	.217		.803	
Item 15			.763	
Item 16			.572	.534
Item 17	.213		.847	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

General Teamwork Perception *(4 items from AHRQ)* — a (4) = .843

Frequent Communication *(1 item written)*

Awareness *(4 items written)* → ***1 item deleted*** — a (3) = .797

Timely Communication *(4 items from Shortell, et al., (1991))* — a (4) = .641

Backstage Communication Concerns *(4 items written)* — a (4) = .796

a (16) = .828

APPENDIX C. PATIENT SURVEY

C.1 A Copy of Patient Survey, Version 1

PATIENT QUESTIONNAIRE

Sex

◯ Male ◯ Female ◯ Prefer not to answer

Age

◯ less than 19 years ◯ 19 to 39 years ◯ 40 to 64 years ◯ 65 years and older

Did you visit the clinic with your family members or friends?

◯ Yes, I came with my family/friends. ◯ No, I came by myself.

Are you a new patient in this clinic?

◯ Yes, I am a new patient. ◯ No, I have visited this clinic previously.

Would you recognize your care team and members of the team?

◯ Yes, I do. ◯ No, I am not sure who my team members are.

Please rate how much you agree or disagree with the following statements regarding staff teamwork and patient involvement on the basis of your visit to the clinic today.

STAFF TEAMWORK	***1* Strongly *Disagree***	***2* Disagree**	***3* Neither Agree nor Disagree**	***4* Agree**	***5* Strongly *Agree***	*Does Not Apply or Don't Know*
1. I liked the way the team worked together						
2. I thought team members enjoyed working together						
3. I thought the team coordinated my care well						
4. I felt as if team members talked in front of me as if I wasn't there						
5. I felt that team members told me conflicting things						
6. I thought team members supported each other to get the work done						
7. I felt team members were considerate of one another						
8. I heard arguments between team members, inside or outside the room						
9. I knew who was in charge						
10. I felt there was good communication between team members						
11. I observed the team working together in the clinic						
12. I saw the team discussing my case						
13. I was cared for by a team of caregivers						
14. This clinic emphasizes teamwork in taking care of patients						
15. I or my family members are considered a member of the care team						
16. I was cared for by an individual provider						

C.2 A Copy of Patient Survey, Version 2

PATIENT QUESTIONNAIRE

Sex

◯ Male ◯ Female ◯ Prefer not to answer

Age

◯ less than 19 years ◯ 19 to 39 years ◯ 40 to 64 years ◯ 65 years and older

Did you visit the clinic with your family members or friends?

◯ Yes, I came with my family/friends. ◯ No, I came by myself.

Are you a new patient in this clinic?

◯ Yes, I am a new patient. ◯ No, I have visited this clinic previously.

How many staff members (including front desk person, nurses, providers, etc.) did you encounter today?

◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ more than 6

Please rate how much you agree or disagree with the following statements regarding teamwork of staff members that you encountered on the basis of your visit to the clinic today.

STAFF TEAMWORK	*1 Strongly* ***Disagree***	*2 Disagree*	*3 Neither Agree nor Disagree*	*4 Agree*	*5 Strongly* ***Agree***	*Does Not Apply*
1. I liked the way the team worked together						
2. I thought team members enjoyed working together						
3. I thought the team coordinated my care well						
4. I felt as if team members talked in front of me as if I wasn't there						
5. I felt that team members told me conflicting things						
6. I thought team members supported each other to get the work done						
7. I felt team members were considerate of one another						
8. I heard arguments between team members, inside or outside the room						
9. I knew who was in charge						
10. I felt there was good communication between team members						
11. I observed the team working together in the clinic						
12. I was cared for by a team of caregivers						
13. This clinic emphasizes teamwork in taking care of patients						
14. I or my family members are considered a member of the care team						

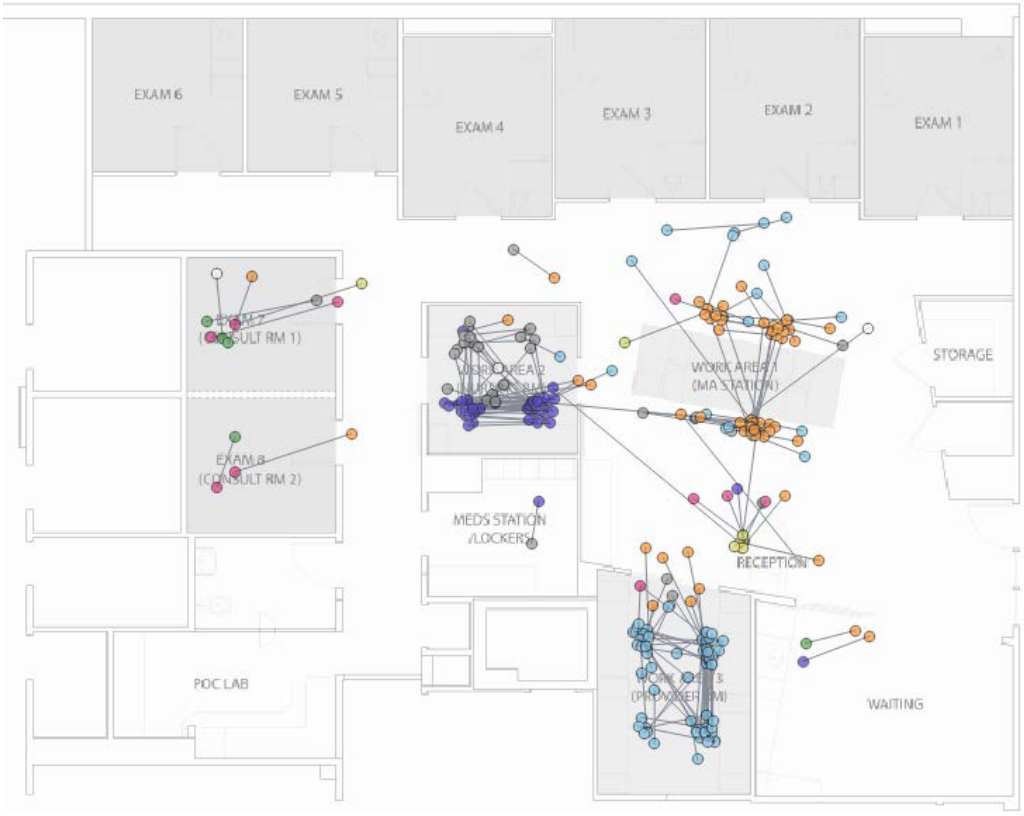
How much do you think the clinic physical space "helps" your care team to work together?

① *Not at all helpful* ② *Not so helpful* ③ *Somewhat helpful* ④ *Very helpful* ⑤ *Extremely helpful*

APPENDIX D. BEHAVIOR MAPPING: LOCATION OF OBSERVED STAFF COMMUNICATIONS

The following figures represent locations of observed staff communications at each clinic. The communications between patients and staff members are not included in the figures.

D.1 Emory Clinic A



D.2 Emory Clinic B

D.3 Mayo Clinic C

D.4 Mayo Clinic D

APPENDIX E. PREFERRED AND NON-PREFERRED LOCATIONS FOR BACKSTAGE COMMUNICATIONS

Table. Results of preferred and non-preferred frequency per space and adjusted preference and non-preference values according to the size of spaces

Space Name	Space Category	Space Size (Points)	Preference Frequency	Not-Preference Frequency	Adj. Preference (Per 100 Points)	Adj. Non-Preference (Per 100 Points)	Mean Patient Exposure Values	Total Patient Points	Patient Exposure Ratio (%)
Clinic A									
Cor1	Corridor	105	0	4	0.00	3.81	57.51	95	60.5%
Cor2	Corridor	140	0	0	0.00	0.00	21.77	95	22.9%
Cor3	Corridor	53	0	2	0.00	3.77	80.25	95	84.5%
Cor4	Corridor	195	2	17	1.03	8.72	81.91	95	86.2%
Cor5	Corridor	53	0	1	0.00	1.89	70.92	95	74.7%
Team_Trans	Team	156	4	17	2.56	10.90	59.52	95	62.7%
ProviderRM	Team	96	27	0	28.13	0.00	11.11	95	11.7%
NurseRM	Team	63	26	2	41.27	3.17	20.37	95	21.4%
MAstation	Team	112	8	14	7.14	12.50	72.97	95	76.8%
Lab	Service	75	10	0	13.33	0.00	0.01	95	0.0%
MedRM	Service	66	6	0	9.09	0.00	0.50	95	0.5%
Clinic B									
Cor1	Corridor	210	0	6	0.00	2.86	62.04	426	14.6%
Cor2	Corridor	122	0	5	0.00	4.10	84.93	426	19.9%
Cor3	Corridor	163	0	13	0.00	7.98	30.54	426	7.2%
Cor4	Corridor	157	0	0	0.00	0.00	99.21	426	23.3%
Front	Front	331	0	7	0.00	2.11	22.79	426	5.4%
TM2_PR	Team	112	2	0	1.79	0.00	15.36	426	3.6%
TM2_LPN	Team	150	6	0	4.00	0.00	51.16	426	12.0%
Cor5	Corridor	147	0	3	0.00	2.04	35.31	426	8.3%
Cor6	Corridor	154	0	6	0.00	3.90	72.05	426	16.9%
Storage	Service	102	0	0	0.00	0.00	30.52	426	7.2%
Break	Break	106	0	2	0.00	1.89	5.47	426	1.3%
Residency	Office	358	4	1	1.12	0.28	5.02	426	1.2%
RN	Team	77	4	0	5.19	0.00	4.82	426	1.1%

Lab	Service	93	0	8	0.00	8.60	5.85	426	1.4%
Med	Service	74	0	0	0.00	0.00	38.80	426	9.1%
TM1_LPN	Team	184	11	0	5.98	0.00	31.75	426	7.5%
TM1_PR	Team	144	6	1	4.17	0.69	43.50	426	10.2%
Call	Office	201	3	0	1.49	0.00	0.16	426	0.0%
Admin	Office	64	0	0	0.00	0.00	5.02	426	1.2%
Cor7	Corridor	173	0	0	0.00	0.00	24.57	426	5.8%
Cor8	Corridor	155	1	0	0.65	0.00	118.00	426	27.7%
Cor9	Corridor	171	0	3	0.00	1.75	114.20	426	26.8%
Cor_T_1	Corridor	120	0	2	0.00	1.67	110.86	426	26.0%
Cor10	Corridor	155	0	3	0.00	1.94	55.07	426	12.9%
Cor11	Corridor	132	0	3	0.00	2.27	72.06	426	16.9%
Cor_T_2	Corridor	120	0	0	0.00	0.00	67.46	426	15.8%
Cor12	Corridor	115	0	0	0.00	0.00	39.03	426	9.2%
Cor13	Corridor	125	1	9	0.80	7.20	55.69	426	13.1%
Cor14	Corridor	130	0	0	0.00	0.00	106.67	426	25.0%
Cor_T_3	Corridor	120	1	9	0.83	7.50	99.20	426	23.3%
Cor15	Corridor	125	0	0	0.00	0.00	109.69	426	25.7%
Clinic C									
Cor1	Corridor	102	0	2	0.00	1.96	83.77	198	42.3%
Cor_T_1	Corridor	198	0	11	0.00	5.56	109.31	198	55.2%
Cor2	Corridor	141	0	3	0.00	2.13	73.86	198	37.3%
Cor3	Corridor	162	0	7	0.00	4.32	89.78	198	45.3%
Cor4	Corridor	161	0	7	0.00	4.35	90.93	198	45.9%
CC_office	Office	42	1	0	2.38	0.00	15.19	198	7.7%
DicRoom	Office	39	1	0	2.56	0.00	19.00	198	9.6%
Huddle	Team	154	23	1	14.94	0.65	17.43	198	8.8%
Team1	Team	113	3	2	2.65	1.77	73.88	198	37.3%
Cor5	Corridor	144	6	2	4.17	1.39	0.32	198	0.2%
Cor_T_2	Corridor	210	0	11	0.00	5.24	106.95	198	54.0%
Cor_T_3	Corridor	216	0	21	0.00	9.72	104.11	198	52.6%
Team2	Team	151	25	8	16.56	5.30	85.74	198	43.3%
Team3	Team	163	28	3	17.18	1.84	89.50	198	45.2%
Team4	Team	190	3	2	1.58	1.05	39.57	198	20.0%
Clinic D									
Cor1	Corridor	200	1	23	0.50	11.50	64.20	353	18.2%
Cor2	Corridor	200	0	2	0.00	1.00	0.27	353	0.1%
Cor3	Corridor	484	0	4	0.00	0.83	5.43	353	1.5%
Cor7	Corridor	220	1	23	0.45	10.45	61.70	353	17.5%
Cor4	Corridor	290	1	29	0.34	10.00	80.99	353	22.9%
Cor5	Corridor	360	1	29	0.28	8.06	61.48	353	17.4%
Cor_T_2	Corridor	336	0	21	0.00	6.25	75.36	353	21.3%
Cor_sccal1	Corridor	48	0	0	0.00	0.00	24.21	353	6.9%
Cor_sccal2	Corridor	35	0	0	0.00	0.00	24.51	353	6.9%
Cor_T_1	Corridor	350	0	21	0.00	6.00	70.62	353	20.0%

Cor6	Corridor	273	0	7	0.00	2.56	54.55	353	15.5%
LPN3	Team	96	1	6	1.04	6.25	12.53	353	3.5%
LPN4	Team	102	4	11	3.92	10.78	11.99	353	3.4%
LPN_cor	Team	88	2	0	2.27	0.00	0.61	353	0.2%
Front	Front	54	0	0	0.00	0.00	0.20	353	0.1%
Meeting1	Team	304	0	0	0.00	0.00	0.33	353	0.1%
Meeting2	Team	88	0	0	0.00	0.00	0.00	353	0.0%
Break	Break	213	1	4	0.47	1.88	0.00	353	0.0%
Locker	Locker	158	0	0	0.00	0.00	0.00	353	0.0%
Cor8	Corridor	110	0	2	0.00	1.82	0.40	353	0.1%
Meeting3	Team	72	0	0	0.00	0.00	0.32	353	0.1%
Team1	Team	272	32	0	11.76	0.00	0.93	353	0.3%
Team2	Team	154	20	0	12.99	0.00	2.87	353	0.8%
LPN2	Team	100	1	5	1.00	5.00	11.84	353	3.4%
LPN1	Team	85	1	5	1.18	5.88	15.29	353	4.3%
Team3	Team	295	16	0	5.42	0.00	0.11	353	0.0%
Team4	Team	199	24	0	12.06	0.00	2.63	353	0.7%
Team_HD1	Team	140	17	0	12.14	0.00	1.34	353	0.4%
Team_Call1	Team	377	9	0	2.39	0.00	1.78	353	0.5%
Team_Call2	Team	377	10	1	2.65	0.27	1.78	353	0.5%
Team_HD2	Team	156	11	0	7.05	0.00	1.33	353	0.4%
Team_table	Team	211	6	3	2.84	1.42	0.53	353	0.1%
Team_adm1	Team	303	3	2	0.99	0.66	1.43	353	0.4%
Team_adm2	Team	220	5	0	2.27	0.00	1.55	353	0.4%
Team_cor1	Team	102	0	0	0.00	0.00	2.28	353	0.6%
Team_cor2	Team	167	2	0	1.20	0.00	3.05	353	0.9%
Team_cor3	Team	57	0	0	0.00	0.00	0.98	353	0.3%
Team_rest	Team	182	1	3	0.55	1.65	0.84	353	0.2%
Team_CC	Team	204	5	0	2.45	0.00	0.18	353	0.1%

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